

**PROJECT MANUAL**

# **NEW RESIDENCE HALL**

**CARROLL DRIVE AT KENTON DRIVE  
HIGHLAND HEIGHTS, KY 41099**

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**NORTHERN KENTUCKY UNIVERSITY**

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**BIDDING and PERMIT  
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VOLUME 2**

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### **GENERAL PROVISIONS - MECHANICAL**

#### **PART 1 – GENERAL:**

- 1.1 The Advertisement for Bid, Instructions to Bidders, Bidding Requirements, General, Special and Supplementary Conditions, and all other Contract Documents shall apply to the Contractor's work as well as to each of their Sub-Contractor's work.
- 1.2 All manufacturers, suppliers, fabricators, contractors, etc. submitting proposals for any part of the work, services, materials or equipment to be used on or applied to this project are hereby directed to familiarize themselves with the Contract Documents. In case of conflict between these General Provisions and the General and/or Special Conditions, the Contractor shall contact the Engineer for clarification and final determination prior to the Bid.
- 1.3 The work included in this Division consists of the furnishing of all labor, equipment, transportation, excavation, backfill, supplies, material, appurtenances and services necessary for the satisfactory installation of the complete and operating Mechanical Systems indicated or specified in the Contract Documents.
- 1.4 Any materials, labor, equipment or services not mentioned specifically herein which may be necessary to complete any part of the Mechanical Systems in a substantial manner, in compliance with the requirements stated, implied or intended in the Plans and/or Specifications, shall be included in the Bid as part of this Contract.
- 1.5 It is not the intent of this Section of the Specifications to make any Contractor, other than the Construction Manager responsible to the Owner. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or materials substitution, shall be routed through the Construction Manager to the Architect, then to the Engineer. Also, this Section of the Specifications shall not be construed as an attempt to arbitrarily assign responsibility of work, material, equipment or services to a particular trade or Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be optional.
- 1.6 The Architect and Engineer do not define the scope of individual trades, subcontractors, material suppliers and vendors. Any sheet numbering system or specification numbering system used which identifies disciplines is solely for the Architect and Engineer's convenience and is not intended to define a subcontractor's scope of work. Information regarding individual trades, subcontractors, material suppliers and vendors may be detailed, described and indicated at different locations throughout the Contract Documents. No consideration will be given to requests for change orders for failure to obtain and review the complete set of Contract Documents when preparing Bids, prices and quotations. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the prime contract.

- 1.7 It is the intent of the Contract Documents to deliver to the Owner a new, complete and operational project once the work is complete. Although Plans and Specifications are complete to the extent possible, it shall be the responsibility of the Contractors involved to remove and/or relocate or re-attach any existing or new systems which interfere with new equipment or materials required for the complete installation without additional cost to the Owner.
- 1.8 In general, all work shall be accomplished without interruption of existing facilities operations. The Contractor shall advise the Owner at least seven (7) days prior to the interruption of any services (gas, domestic water, heating, etc.). The Owner shall be advised of the exact time that interruption will occur and the length of time the interruption will last. Failure to comply with this requirement may result in complete work stoppage for the Contractors involved until a complete schedule of interruptions can be developed.
- 1.9 Whenever utilities are interrupted, either deliberately or accidentally, the Contractor shall work continuously to restore said service. The Contractor shall provide tools, materials, skilled journeymen of Bidder/Proposer's own and other trades as necessary, premium time as needed and coordination with all applicable utilities, including payment of utility company charges (if any), all without requests for extra compensation from the Owner.
- 1.10 Each Bidder/Proposer shall also be governed by any unit prices and Addenda insofar as they may affect part of their work or services.
- 1.11 DEFINITIONS AND ABBREVIATIONS:
- Contractor - Any Contractor whether bidding, proposing or working independently or under the supervision of a Construction Manager and who installs any type of Mechanical Work as specified in the Contract Documents or, the General Contractor.
  - Engineer - The Consulting Mechanical-Electrical Engineer either consulting to the Owner, Architect, or Other, etc. In this case: CMTA, Inc., Consulting Engineers.
  - Architect - The Architect of Record for the project.
  - Contract Documents - All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, Instructions to Bidders, General and Special Conditions, Addenda, Alternates, Lists of Materials, Lists of Sub-Contractors, Unit Prices, Shop Drawings, Field Orders, Change Orders, Cost Breakdowns, Schedules of Value, Periodical Payment Requests, Construction Contract with Owner, etc.
  - Bidder/Proposer - Any person, agency or entity submitting a proposal to any person, agency or entity for any part of the work required under this contract.
  - The Project - All of the work required under this Contract.
  - Furnish - Deliver to the site in good condition and turn over to the Contractor who is to install.
  - Provide - Furnish and install complete, tested and ready for operation.
  - Install - Receive and place in satisfactory operation.
  - Indicated - Listed in the Specifications, shown on the Plans or Addenda thereto.
  - Typical or Typ.- Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.
  - ADA - Americans with Disabilities Act.
  - AGA - American Gas Association.

- ANSI - American National Standards Institute.
- ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers.
- ASME - American Society of Mechanical Engineers.
- IBC - International Building Code.
- NEC - National Electrical Code.
- NEMA - National Electrical Manufacturers Association.
- NFPA - National Fire Protection Association.
- OSHA - Office of Safety and Health Administration.
- SMACNA - Sheet Metal and Air Conditioning Contractors National Association.
- UL - Underwriters Laboratories.

**PART 2 – INTENT AND INTERPRETATION:**

- 2.1 It is the intention of the Contract Documents to call for a complete and operational system, including all components, accessories, finish work, etc as necessary for trouble free operation; tested and ready for operation. Anything that may be required, implied, or inferred by the Contract Documents shall be provided and included as part of the Bid.
- 2.2 Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.
- 2.3 The Bidder/Proposer shall completely review the Contract Documents. Any interpretation as to design intent or scope shall be provided by the Engineer / Architect. Should an interpretation be required, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event of any conflict, discrepancy, or inconsistency develops; the interpretation of the Engineer shall be final.
- 2.4 The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten (10) days prior to bid. In the absence of such written notice and by the act of submitting a bid, it shall be understood that the Contractor has included the cost of all required items in the bid, and that will be responsible for the approved satisfactory functioning of the entire system without extra compensations.

**PART 3 – PLANS AND SPECIFICATIONS:**

- 3.1 The Plans are diagrammatic only and indicate the general arrangement of the systems and are to be followed. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted to the Engineer for approval before proceeding with the work. The Plans are not intended to show every item which may be necessary to complete the systems. All Bidder/Proposers shall anticipate that additional items may be required and submit their Bid accordingly.

- 3.2 The Plans and Specifications are intended to supplement each other. No Bidder/Proposer shall take advantage of conflict between them, or between parts of either. Should this condition exist, the Bidder/Proposer shall request a clarification not less than ten (10) days prior to the submission of the proposal so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be final.
- 3.3 The Plans and Specifications shall be considered to be cooperative and anything appearing in the Specifications which may not be indicated on the Plans or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.
- 3.4 Contractor shall make all of their own measurements in the field and shall be responsible for correct fitting. The work shall be coordinated with all other branches of work in such a manner as to cause a minimum of conflict or delay.
- 3.5 The Engineer shall reserve the right to make adjustments in location of piping, ductwork, equipment, etc. where such adjustments are in the interest of improving the project.
- 3.6 Should conflict, overlap or duplication of work between the various trades become evident, this shall be called to the attention of the Engineer. In such event neither trade shall assume to be relieved of the work which is specified under their branch until instructions in writing are received from the Engineer.
- 3.7 Unless dimensioned, the Plans only indicate approximate locations of equipment, piping, ductwork, etc. Dimensions given in figures on the Plans shall take precedence over scaled dimensions and all dimensions, whether given in figures or scaled, shall be verified in the field to insure no conflict with other work.
- 3.8 Each Bidder/Proposer shall review all Plans in the Contract Documents to insure that the work they intend to provide does not create a conflict with or affect the work of others in any way. Where such effect does occur, it shall be the Bidder/Proposer's responsibility to satisfactorily eliminate any such conflict or effect prior to the submission of their proposal. Each Bidder/Proposer shall in particular insure that there is adequate space to install their equipment and materials. Failure to do so shall result in the correction of such encroachment conflict or effect of any work awarded the Bidder/Proposer and shall be accomplished fully without expense to others and that they are reasonably accessible for maintenance. Check closely all mechanical and electrical closets, chases, ceiling voids, wall voids, crawl spaces, etc., to insure adequate spaces.
- 3.9 Where on the Plans a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornamentation or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.
- 3.10 Details not usually shown or specified, but necessary for the proper installation and operation of systems, equipment, materials, etc., shall be included in the work, the same as if herein specified or indicated.

- 3.11 Where within the Contract Documents the word "typical" or "typ." is used, it shall mean that the work method or means indicated as typical shall be repeated in and each time it occurs whether indicated or not.
- 3.12 Each Contractor shall evaluate ceiling heights specified on Architectural Plans. Where the location of equipment or systems may interfere with ceiling heights or maintenance and access of equipment or systems, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Do not install equipment or systems in the affected area until the conflict is resolved. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work or cost incurred on the part of the Contractor or unduly delay the work.

**PART 4 – EXAMINATION OF SITE AND CONDITIONS:**

- 4.1 Each Bidder/Proposer shall inform themselves of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, above and below grade, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work.
- 4.2 Each Bidder/Proposer shall also fully acquaint themselves with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of utilities, etc. A proposal shall cover all expenses or disbursements in connection with such matters and conditions. No allowance will be made for lack of knowledge concerning such conditions after Bids are accepted.

**PART 5 – EQUIPMENT AND MATERIALS SUBSTITUTIONS OR DEVIATIONS:**

- 5.1 When any Contractor requests approval of materials and/or equipment of different physical size, weight, capacity, function, color, access, that the design allows for it shall be understood that such substitution, if approved, will be made without additional cost to anyone other than the Contractor requesting the change regardless of changes in connections, space requirements, electrical characteristics, etc. from that indicated, electrical service, etc. In all cases where substitutions affect other trades, the Contractor requesting such substitutions shall advise all such Contractors of the change and shall compensate them for all necessary changes in their work. Any Plans, Specifications, Diagrams, etc., required to describe and coordinate such substitutions or deviations shall be professionally prepared at the responsible Contractor's expense. Review of Shop Drawings by the Engineer does not in any way absolve the Contractor of this responsibility.
- 5.2 Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form, or type of construction by name, make or catalog number, such reference shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition; any devices, products, materials, fixtures, forms, or types of construction which, in the judgment of the Engineer, are equivalent to those specified are acceptable, provided the provisions of this Part are met. Requested substitutions shall be submitted to the Engineer a minimum of ten (10) days prior to Bid. If this procedure is not followed, the substitution will be rejected. If prevailing laws of

cities, towns, states or countries are more stringent than these specifications regarding such substitutions, then those laws shall prevail over these requirements.

- 5.3 Wherever any equipment and material is specified exclusively only such items shall be used unless substitution is accepted in writing by the Engineer.
- 5.4 Each Bidder/Proposer shall furnish along with their proposal a list of specified equipment and materials which is to be provided. Where several makes are mentioned in the Specifications and the Contractor fails to state which they propose to furnish, the Engineer shall choose any of the makes mentioned without change in price. Inclusion in this list shall not insure that the Engineer will approve shop drawings unless the equipment, materials, etc., submitted in shop drawings are satisfactorily comparable to the items specified and/or indicated.
- 5.5 Coordinate kitchen equipment selection by the General Contractor prior to Bid. Any deviations and/or conflicts for any kitchen equipment shall be the Contractor's responsibility.

**PART 6 – CODES, RULES, PERMITS, FEES, INSPECTIONS, REGULATIONS, ETC.:**

- 6.1 The Contractor shall give all necessary notices, obtain and pay for all permits, government sales taxes, fees, inspections and other costs, including all utility connections, meters, meter settings, taps, tap fees, extensions, etc. in connection with their work. They shall also file all necessary plans, prepare all documents and obtain all necessary approvals of all governmental departments and/or the appropriate municipality or utility company having jurisdiction, whether indicated or specified or not. They shall also obtain all required certificates of inspection for their work and deliver same to the Engineer before request for acceptance and final payment for the work.
- 6.2 Ignorance of Codes, Rules, regulations, utility company requirements, laws, etc., shall not diminish or absolve Contractor's responsibilities to provide and complete all work in compliance with such.
- 6.3 The Contractor shall include in their work, without extra cost, any labor, materials, services, apparatus and Plans in order to comply with all applicable laws, ordinances, rules and regulations, whether or not indicated or specified.
- 6.4 All materials furnished and all work installed shall comply with the National Fire Codes of the National Fire Protection Association, with the requirements of local utility companies, or municipalities and with the requirements of all governmental agencies having jurisdiction.
- 6.5 All materials and equipment so indicated and all equipment and materials for the electrical portion of the mechanical systems shall bear the approval label of, or shall be listed by the Underwriters' Laboratories (UL), Incorporated. Each packaged assembly shall be approved as a package. Approval of components of a package shall not be acceptable.
- 6.6 All plumbing work is to be constructed and installed in accordance with applicable codes, Plans and Specifications which have been approved in their entirety and/or reflect any

changes requested by the Authority Having Jurisdiction. Plumbing work shall not commence until such Plans are in the possession of the Plumbing Contractor.

- 6.7 All Heating, Ventilation and Air Conditioning work shall be accomplished in accordance with the Building Code and amendments thereto, the latest standards recognized by the American Society of Heating, Refrigerating and Air Conditioning and the National Fire Protection Association.
- 6.8 The Contractor shall furnish three (3) copies of all Final Inspection Certificates obtained to the Engineer when work is complete. Final payment for work will be contingent upon compliance with this requirement.
- 6.9 Where minimum code requirements are exceeded in the Design, the Design shall govern.
- 6.10 The Contractor shall insure that their work is accomplished in accord with the OSHA Standards and that they conduct their work and the work of their personnel in accord with same.
- 6.11 All work relating to the handicapped shall be in accord with regulations currently enforced by the Authority Having Jurisdiction and the American Disabilities Act.
- 6.12 All pressure vessel installations shall comply with the State, and/or Federal Code applicable. A Certificate of Final Boiler Inspection shall be required.
- 6.13 Work in elevators, elevator shafts and elevator equipment rooms shall comply with the Elevator Code enforced by the Authority Having Jurisdiction.
- 6.14 All work in conjunction with a natural gas installation shall, in addition to all other Codes, Rules, Regulations, Standards, etc., comply with the requirements of the local gas supplier and/or standards and recommendations of the American Gas Association.
- 6.15 All work in relation to domestic water systems shall, in addition to all other Codes, Rules, Regulations and Standards, be in compliance with the requirements of the local water utility company.
- 6.16 All work in relation to the installation of sanitary or storm sewers shall, in addition to all other Codes, Rules, Regulations and Standards, be in compliance with the local agency governing such installations.
- 6.17 Discharge of any toxic, odorous or otherwise noxious materials into the atmosphere or any system shall be subject to regulations of the Environmental Protection Agency (EPA) and/or the air pollution control commission. If in doubt, contact the State Department for Environmental Protection.
- 6.18 Where conflict arises between any code and the Plans and/or Specifications, the code shall apply except in the instance where the Plans and Specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten (10) days prior to bid date, otherwise the Contractor shall make the required changes at their own expense.

**PART 7 – QUALIFICATIONS OF CONTRACTOR/WORKERS:**

- 7.1 All Mechanical Contractors and their subcontractors bidding this project must have been a licensed company for a minimum of three (3) years to qualify to Bid this project. Individual employee experience does not supersede this requirement.
- 7.2 All mechanical subcontractors bidding the mechanical work must have completed one project of 70% this subcontract cost size and two projects of 50% this subcontract cost size.
- 7.3 All mechanical work shall be accomplished by qualified workers competent in the area of work for which they are responsible. Untrained and incompetent workers, as evidenced by their workmanship, shall be summarily relieved of their responsibilities in areas of incompetency. The Engineer shall reserve the right to determine the quality of workmanship of any workers and unqualified or incompetent workers shall refrain from work in areas not deemed satisfactory. Requests for relief of workers shall be made through the normal channels of Architect, Contractor, etc.
- 7.4 All plumbing work shall be accomplished by Journeymen Plumbers under the direct supervision of a Master Plumber as defined under State Plumbing Law Regulations and Code. Proof and Certification may be requested by the Engineer.
- 7.5 The installation of all Heating, Ventilating and Air-Conditioning Systems (HVAC) by any Contractor, whether in existing or new building construction shall be performed by a Licensed Master HVAC Contractor. This includes any Contractor installing HVAC systems, piping and ductwork.
- 7.6 All sheet metal, insulation and pipe fitting work shall be installed by workers normally engaged in this type work.
- 7.7 All automatic control systems shall be installed by workers normally engaged or employed in this type work, except in the case of minor control requirements (residential type furnaces, packaged HVAC equipment with integral controls, etc.) in which case, if a competent worker is the employee of this Contractor, the worker may be utilized subject to review of their qualifications by the Engineer and after written approval from same.
- 7.8 All special systems (Medical Gases, Automatic Sprinkler Equipment, etc.) shall be installed only by workers normally engaged in such services. Exception to this specification may only be made in writing by the Engineer.
- 7.9 All electrical work shall be accomplished by Licensed Journeymen electricians under the direct supervision of a licensed Electrician. All applicable codes, utility company regulations, laws and permitting authority of the locality shall be fully complied with by the Contractor.

**PART 8 – SUPERVISION OF WORK:**

- 8.1 The Contractor shall personally supervise the work for which they are responsible or have a competent superintendent, approved by the Engineer, on the work at all times during progress with full authority to act on behalf of the Contractor.

**PART 9 – CONDUCT OF WORKERS:**

- 9.1 The Contractor shall be responsible for the conduct of all workers under their supervision. Misconduct on the part of any worker to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt removal of that worker. The consumption of alcoholic beverages or other intoxicants, narcotics, barbiturates, hallucinogens or debilitating drugs on the job site is strictly forbidden.

**PART 10 – COOPERATION AND COORDINATION WITH OTHER TRADES:**

- 10.1 The Contractor shall give full cooperation to all other trades and shall furnish in writing with copies to the Engineer, any information necessary to permit the work of other trades to be installed satisfactorily and with the least possible interference or delay.
- 10.2 Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If so directed by the Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than  $\frac{1}{4}" = 1'-0"$ , clearly indicating how their work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. Make the necessary changes in the work to correct the condition without extra charge.
- 10.3 The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

**PART 11 – GUARANTEES AND WARRANTIES:**

- 11.1 The Contractor shall guarantee all equipment, apparatus, materials, and workmanship entering into their Contract to the best of its respective kind and shall replace all parts at their own expense, which are proven defective within the time frame outlined in the General Conditions of the Contract. The effective date of completion of the work shall be the date of the Project's Statement of Substantial Completion. Items of equipment which have longer guarantees, as called for in these Specifications, shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer. The Contractor shall present the Engineer with such warranties and guarantees at the time of final acceptance of the work. The Engineer shall then submit these warranties, etc. to the Owner. The Owner reserves the right to use equipment installed by the Contractor prior to date of final acceptance. Such use of equipment shall not invalidate the guarantee except that the Owner shall be liable for any damage to equipment during this period, due to negligence of their operator or other employees. Refer to other sections for any special or extra warranty requirements.

- 11.2 All compressors shall have five-year warranty. (1<sup>st</sup> year parts and labor, 2<sup>nd</sup> thru 5<sup>th</sup> year compressor parts only).
- 11.3 All VFD's shall have a two-year warranty. (Parts and Labor).
- 11.4 Building Automation system shall have a 2-year warranty.
- 11.5 Geothermal wellfield shall be warranted for 5 years (parts and labor, including any cut, patch, and repair work required to access work).
- 11.6 Provide all warranty certificates to Owner. All warranties begin starting at the substantial completion date, submit warranty certificates accordingly.

**PART 12 – COST BREAKDOWNS (SCHEDULE OF VALUES):**

- 12.1 Within thirty (30) days after acceptance of the Contract, the Contractor shall furnish to the Engineer, one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made in a format approved by the Engineer. Payments will not be made until satisfactory cost breakdowns are submitted.
- 12.2 The breakdown shall be minimally as follows. Material and labor shall be listed separately. Pay special attention to required withholding percentages for startup, testing, documentation, acceptance, owner training, etc.:
- Mechanical Shop Drawings
  - Mechanical Record Drawings & Acceptance
  - Mechanical O&M Manuals & Acceptance
  - Mechanical Owner Training & Acceptance
  - Spare Parts
  - Coordination Drawings
  - Mechanical Identification Materials & Labor
  - Heat Pump Condenser Piping Materials & Labor
  - Heat Pump Condenser Piping Testing, Cleaning, Documentation, Acceptance, etc.
  - Heat Pump Condenser Piping Purging, Flushing, Cleaning
  - Refrigerant piping Materials & Labor
  - Condensate Piping Materials & Labor
  - Insulation (Piping) Materials & Labor
  - Insulation (Ductwork) Materials & Labor
  - Geothermal Materials & Labor
  - Geothermal Vault Materials & Labor
  - Geothermal Grouting Materials & Labor
  - Geothermal Flushing, Purging, Testing, Documentation, Site Survey Submittal, Acceptance, etc.
  - Plumbing Fixtures and Equipment
  - Underground Sanitary Materials, Piping & Labor
  - Above Ground Sanitary & Vent Piping Materials & Labor
  - Domestic Water Piping Materials & Labor
  - Plumbing Insulation

- Domestic Water Heater Equipment & Labor
- Domestic Water Heater Startup, Testing, Documentation, Training, Acceptance, etc.
- Fire Protection Shop Drawings
- Fire Protection Materials & Labor
- Fire Protection Record Drawings & Acceptance
- Sheetmetal Equipment
- Sheetmetal Materials & Labor
- Sheetmetal Shop Fabrication
- Ductwork Air Leakage Testing, Documentation, Acceptance, etc.
- Filters and Racks Materials & Labor
- Heat Pump Equipment & Labor
- Heat Pump Startup, Testing, Documentation, Training, Acceptance, etc.
- Packaged Outside Air Handling Unit Equipment & Labor
- Packaged Outside Air Handling Unit Startup, Testing, Documentation, Training, Acceptance, etc.
- Ductless Split System Equipment & Labor
- Ductless Split System Startup, Testing Equipment Room A/C Equipment & Labor
- Other HVAC Equipment & Labor
- Other HVAC Equipment Startup, Testing, Documentation, Training, Acceptance, etc.
- Chemical Treatment Materials & Labor
- Chemical Treatment Pre-Testing
- Chemical Treatment Startup, Testing, Documentation, Training, Acceptance, etc.
- Controls Front-end Interface
- Controls Commissioning Plan
- Controls Shop Drawings
- Controls Materials & Labor
- Controls Graphics
- Controls Record Drawings
- Controls Startup, Commissioning, Testing, Documentation, etc.
- Controls Training and Acceptance
- Test and Balance Materials & Labor
- Test and Balance Initial Report, Final Report and Acceptance

**PART 13 – CHANGES IN MECHANICAL WORK:**

13.1 REFER TO GENERAL AND SPECIAL CONDITIONS.

**PART 14 – CLAIMS FOR EXTRA COST:**

14.1 REFER TO GENERAL AND SPECIAL CONDITIONS.

**PART 15 – MATERIALS AND WORKMANSHIP:**

15.1 All equipment, materials and articles incorporated in the work shall be new and of comparable quality to that specified. Each Bidder/Proposer shall determine that the materials and/or equipment they propose to furnish can be brought into the building(s) and installed within the space available. In certain cases, it may be necessary to remove and replace walls, floors and/or ceilings and/or disassemble/reassemble the

materials and equipment and this work shall be the responsibility of the Contractor, whether specifically initiated or not.

- 15.2 All equipment shall be installed so that all parts are readily accessible for inspection, maintenance, replacement of fans, motors, coils, filters, etc. Extra compensation will not be allowed for relocation of equipment for accessibility or for dismantling equipment to obtain entrance into the building(s). Insure, through coordination that no other Contractor seals off access to space required for equipment materials, etc.
- 15.3 Materials and equipment shall bear Underwriters' Laboratories label where such a standard has been established, where applicable.
- 15.4 Each length of pipe, fitting, trap, fixture and device used in the plumbing or drainage systems shall be stamped or indelibly marked with the weight or quality thereof and with the manufacturer's mark or name.
- 15.5 All equipment shall bear the manufacturer's name and address. All electrically operated equipment shall bear a name plate indicating required horsepower, voltage, phase and ampacity. Pumps and fans shall have a data plate indicating horsepower, pressure and flow rate.

**PART 16 – HAZARDOUS MATERIALS:**

- 16.1 The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building or site.
- 16.2 Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of their work, ensure that their workers are aware of this potential and what they are to do in the event of suspicion. The Contractor shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.
- 16.3 CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling or disposal of such material.
- 16.4 If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise them immediately.
- 16.5 The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents or consultants. Also, the Contractor further agrees to defend, indemnify and hold CMTA, its principals, employees, agents and consultants,

harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.

16.6 No asbestos or mercury containing materials shall be installed in this project.

**PART 17 – TEMPORARY SERVICES:**

17.1 The Contractor shall arrange any temporary water, electrical and other services which may be required to accomplish the work. Refer also to General and Special Conditions.

17.2 All temporary services shall be removed by Contractor prior to completion of work.

**PART 18 – SURVEY, MEASUREMENTS AND GRADE:**

18.1 The Contractor shall lay out their work and be responsible for all necessary lines, levels, inverts, elevations and measurements. The Contractor must verify the figures shown on the Plans before laying out the work and will be held responsible for any error resulting from failure to do so.

18.2 The Contractor shall base all measurements, both horizontal and vertical from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at the site and check the correctness of same as related to the work.

18.3 Should the Contractor discover any discrepancy between actual measurements and those indicated which prevents following good practice or the intent of the contract documents, the Contractor shall promptly notify the Engineer and shall not proceed with this work until the Contractor has received instructions from the Engineer on the disposition of the work.

**PART 19 – PROTECTION OF EQUIPMENT:**

19.1 The Contractor shall be entirely responsible for all material and equipment they furnish in connection with their work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. All piping, etc., shall be properly plugged or capped during construction in a manner approved by the Engineer. Equipment damaged, stolen or vandalized while stored on site, either before or after installation, shall be repaired or replaced by the Contractor at their expense. All ductwork with open ends shall be covered with plastic during construction.

**PART 20 – REQUIRED CLEARANCES FOR ELECTRICAL EQUIPMENT:**

20.1 The NEC has specific required clearances above, in front, and around electrical gear, panels etc. The Contractor shall not install any piping, ductwork, etc., in the required clearance. If any appurtenance is located in the NEC required clearance, it shall be relocated at no additional cost. Coordinate with the Electrical Contractor prior to any work.

**PART 21 – EQUIPMENT SUPPORT:**

- 21.1 Each piece of equipment, apparatus, piping, or conduit suspended from the ceiling or mounted above the floor level shall be provided with suitable structural support, pipe stand, platform or carrier in accordance with the best recognized practice. Such supporting or mounting means shall be provided by the Contractor for all equipment and piping. Exercise extreme care that structural members of building are not overloaded by such equipment. Provide any required additional bracing, cross members, angles, support, etc. Do not support items from roof/floor deck or bridging.

**PART 22 – DUCT AND PIPE MOUNTING HEIGHTS:**

- 22.1 All exposed or concealed ductwork, piping, etc., shall be held as high as possible unless otherwise noted and coordinated with all other trades. Exposed piping and ductwork shall, insofar as possible, run perpendicular or parallel to the building structure. Refer to Plans for minimum heights of ducts and piping. Minimum height above ceilings shall be 6" clear including insulation, unless otherwise noted.

**PART 23 – BROKEN LINES AND PROTECTION AGAINST FREEZING:**

- 23.1 No conduits, piping, etc. carrying water or any other fluid subject to freezing shall be installed in any part of the building where danger of freezing may exist without adequate protection being given by the Contractor whether or not insulation is specified or indicated on the particular piping. All damages resulting from broken and/or leaking lines shall be replaced or repaired at the Contractor's own expense. Do not install piping across or near openings to the outside whether or not they are carrying static or moving fluids. Insulation on piping does not necessarily insure that freezing will not occur. If in doubt, contact the Engineer.

**PART 24 – WEATHERPROOFING:**

- 24.1 Where any work pierces waterproofing including waterproof concrete, the method of installation shall be as specified and approved by the Architect and Engineer before work is performed. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings permanently watertight.
- 24.2 Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

**PART 25 – FINAL CONNECTIONS TO EQUIPMENT:**

- 25.1 The Contractor shall finally connect mechanical services (water, sanitary, gas, air, etc.), to any terminal equipment, appliances, kitchen equipment, etc., provided under this and/or other divisions of the work. Various equipment connections indicated are based upon "basis of design" equipment selections. Should alternate equipment be purchased by the General Contractor, then this Contractor shall make the necessary provisions in the Bid for any and all differences. Change Orders shall not be considered for any differences due to alternate equipment purchase. Such connections shall be made in

strict accord with current codes, safety regulations and the equipment manufacturer's recommendations. If in doubt, contact the Engineer prior to installation.

**PART 26 – ACCESSIBILITY:**

- 26.1 The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in double partitions and ceilings for the proper installation of their work. They shall cooperate with all others whose work is in the same space. Such spaces and clearances shall, however, be kept to the minimum size required.
- 26.2 The Contractor shall locate and install all equipment so that it may be serviced, and maintained as recommended by the manufacturer. Allow ready access and removal of the entire unit and/or parts such as valves, filters, fan belts, motors, prime shafts, controls, coils, etc.
- 26.3 Whether shown on the Plans or not, the Contractor shall provide in the Bid access panels for each concealed shut-off valve, motorized control damper, manual air damper or other device requiring service as shown on Engineer's Plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. Change orders for access panels will not be accepted.

**PART 27 – SCAFFOLDING, RIGGING AND HOISTING:**

- 27.1 The Contractor shall furnish all scaffolding, rigging, hoisting and services necessary for erection and delivery onto the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OHSA Standards and Requirements. Remove same from premises when no longer required.

**PART 28 – CONCRETE WORK:**

- 28.1 The Contractor shall be responsible for the provisions of all concrete work required for the installation of any of their systems or equipment. The Contractor may, at their option, arrange with the others to provide the work. This option, however, will not relieve the Contractor of their responsibilities relative to dimensions, quality of workmanship, locations, etc.
- 28.2 All concrete pads shall be complete with all pipe sleeves, anchor bolts, reinforcing steel, concrete, etc. as required. Pads larger than 18" in width shall be reinforced with ½" deformed round bars on 6" centers both ways. Bars shall be approximately 2" above the bottom of the pad. All parts of pads and foundations shall be properly rodded or vibrated. If exposed parts of the pads and foundations are rough or show honeycomb after removing forms, all surfaces shall be rubbed to a smooth surface. Chamfer all vertical edges ¾" and tool horizontal edges with ¾" radius.
- 28.3 In general, unless otherwise noted, concrete pads for equipment shall be 4" thick, extend six (6) inches beyond the equipment's base dimensions. Where necessary, extend pads 30 inches beyond base or overall dimensions to allow walking and servicing space.
- 28.4 Exterior concrete pads shall be 8" thick with four (4) inches minimum above grade and four (4) inches below grade on a compacted four (4) inch dense grade rock base unless

otherwise indicated or specified. Surfaces of all foundations and bases shall have a smooth finish with one-half (½) inch chamfer on exposed edges. Turn down edges 18" below grade.

**PART 29 – RESTORATION OF NEW OR EXISTING LANDSCAPING, PAVING, SURFACES, ETC.:**

- 29.1 The Contractor shall at their expense restore to their original conditions all paving, curbing, surfaces, drainage ditches, structures, fences, landscaping, existing or new building surfaces and appurtenances, and any other items damaged or removed by their operations. Replacement and repairs shall be in accordance with good construction practice; by qualified tradesman, and shall match materials employed in the original construction of the item and shall be to the satisfaction of the Owner and/or Engineer.

**PART 30 – MAINTENANCE OF EXISTING UTILITIES AND LINES:**

- 30.1 The locations of all piping, conduits, cables, utilities and manholes existing, or otherwise, that comes within the contract construction site, shall be subject to continuous uninterrupted service with no other exception than the Owner of the utilities permission to interrupt same temporarily. Provide a seven (7) day written notice to Engineer, Architect and Owner prior to interrupting any utility service or line.
- 30.2 Known utilities and lines as available to the Engineer are shown on the Plans. However, it is additionally required that, prior to any excavation being performed, each Contractor ascertain and mark all utilities or lines that would be endangered by the excavation. Hand dig if required to locate. Contractor shall bear costs of repairing damaged utilities.
- 30.3 If utilities or lines occur in the earth within the construction site, the Contractor shall probe and locate the lines prior to machine excavation in the respective area. Hand dig if required to locate.
- 30.4 Cutting into existing utilities and services shall be performed in coordination with and as designated by the Owner of the utility. The Contractor shall work continuously to restore service(s) upon deliberate or accidental interruption, providing premium time and materials as needed without extra claim to the Owner.
- 30.5 The Contractor shall repair to the satisfaction of the Owner and Engineer, any surfaces or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.
- 30.6 Machine excavation shall not be permitted with ten feet of gas lines, fuel lines, electrical lines or lines carrying combustible and/or explosive materials. Hand excavate only in accord with utility company, agency or other applicable laws, standards or regulations.
- 30.7 Protect all new or existing lines from damage by traffic, etc. during construction. Repairs or replacement of such damage shall be at the sole expense of the party responsible.
- 30.8 Protect existing trees, indicated to remain with fencing or other approved method. Hold all new subsurface lines outside the drip line of trees, offsetting as necessary to protect

root structures. Refer to planting or landscaping plans, or in their absence, consult with the Architect.

**PART 31 – CLEANING:**

- 31.1 The Contractor shall, at all times, keep the area of their work presentable to the public and clear from rubbish and debris caused by their operations; and at the completion of the work, they shall remove all rubbish, debris, all of their tools, equipment, temporary work and surplus materials from and about the premises, and shall leave the area clean and ready for use. If the Contractor does not attend to such cleaning upon request, the Engineer may cause cleaning to be done by others and charge the cost of same to the Contractor. The Contractor shall be responsible for all damage from fire which originates in, or is propagated by, accumulations of their rubbish or debris.
- 31.2 After completion of all work and before final acceptance of the work, the Contractor shall thoroughly clean all equipment and materials and shall remove all foreign matter such as grease, dirt, plaster, labels, stickers, etc., from the exterior of piping, equipment, fixtures and all other associated or adjacent fabrication.
- 31.3 Ductwork and piping shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic. Do not install the ductwork or insulation (pipe or duct) if the building is not "dried-in". If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.

**PART 32 – TEMPORARY USE OF EQUIPMENT:**

- 32.1 The permanent heating and plumbing equipment, when installed, may be used for temporary services, with the consent of the Engineer. Should the permanent systems be used for this purpose the Contractors shall make all temporary connections required at their expense. They shall also make any replacement required due to damage wear and tear, etc., leaving the same in "as new" condition.
- 32.2 Permission to use the permanent equipment does not relieve the Contractors from the responsibility for any damages to the building construction and/or equipment which might result because of its use.
- 32.3 Warranties shall begin at substantial completion regardless of temporary use of equipment or not.
- 32.4 A pre-start-up conference shall be held in accordance with EQUIPMENT/CONTROLS START-UP AND VERIFICATION in this section.
- 32.5 For Heat Pump Units during all phases of construction:
- At a minimum, four complete sets of filter media are required for each unit. In each unit, install two sets of filter media during construction (more shall be required if construction activities dictate more frequent changes). In each unit, install one set of

filter media at substantial completion. Leave one set of filter media in boxes in appropriate mechanical room as a spare set for the Owner. All other filters shall be used by the Contractor during construction. Dispose of all construction filter media.

- On the outside of all exhaust air openings install a minimum of two sets of fiberglass filter media, such as cheesecloth, to be utilized as pre-filters for the “construction” filters. Install first set upon start-up and then install second set when first set is dirty. Dispose of all dirty construction filters. Change filters as often as necessary to keep units from becoming dirty at no additional cost.
- At substantial completion of the project the entire unit shall be cleaned to present a like “new” unit for the Owner and all filters shall be replaced with new.

32.6 For Outside Air Units during all phases of construction:

- These units shall not be used for temporary heating and cooling by the Contractor. They shall, however, be made operational, tested, etc. as specified during construction by the Contractor. Three complete sets of filters are required for each unit. In each unit, install one set of filters during construction. In each unit, install one set of filters at substantial completion. For each unit, leave third set of filters in boxes in appropriate mechanical room as a spare set for the Owner. Dispose of all construction filters.
- At substantial completion of the project the entire unit shall be cleaned to present a like “new” unit for the Owner and all filters shall be replaced with new.

**PART 33 – NOISE, VIBRATION OR OSCILLATION:**

- 33.1 All work shall operate under all conditions of load without any sound or vibration which is objectionable in the opinion of the Engineer. In case of moving machinery, sound or vibration noticeable outside of room in which it is installed, or annoyingly noticeable inside its own room, will be considered objectionable. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor at their expense.
- 33.2 All equipment subject to vibration and/or oscillation shall be mounted on vibration supports whether indicated or not suitable for the purpose of minimizing noise and vibration transmission, and shall be isolated from external connections such as piping, ducts, etc. by means of flexible connectors, vibration absorbers, or other approved means.
- 33.3 Unitary equipment, such as room units, exhaust fans, etc., shall be rigidly braced and mounted to wall, floor or ceiling as required and tightly gasketed and sealed to mounting surface to prevent air leakage and to obtain quiet operation. Flush and surface mounted equipment such as diffusers, grilles, etc., shall be gasketed and affixed tightly to their mounting surface.
- 33.4 The Contractor shall provide supports for all equipment they furnish. Supports shall be liberally sized and adequate to carry the load of the equipment and the loads of attached equipment, piping, etc. All equipment shall be securely fastened to the structure either directly or indirectly through supporting members by means of bolts or equally effective means. If strength of supporting structural members is questionable, contact Engineer.

**PART 34 – EQUIPMENT/CONTROLS STARTUP & VERIFICATION:**

- 34.1 The Contractor and their Subcontractors shall include in the bid to provide equipment and controls startup and verification for ALL Mechanical Systems specified for this project.
- 34.2 A pre-start-up conference shall be held with the Architect, Engineer, Owner, General Contractor, Mechanical Contractor, Electrical Contractor, Controls Contractor, Test and Balance Contractor, and the Manufacturer's providing startup services. The purpose of this meeting will be to discuss the goals, procedures, etc. for start-up.
- 34.3 Specific line-items shall be included on the schedule of values by each Trade for "equipment and controls startup". These line-item values shall be approved by the Engineer. The Engineer, Owner and the Engineer's Field Inspector(s) shall closely monitor progress and quality of the equipment and controls startup and may withhold pay requests as deemed appropriate until satisfactorily completed.
- 34.4 Specific startup/verification specifications are included throughout the Mechanical Specifications. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians, not third-party contractors, and shall complete and submit start-up reports/checklists. The Contractor shall have appropriate trades on site to correct all deficiencies noted by the factory representative. For each deficiency noted, documentation of corrective action (including date and time) shall be submitted to the Engineer and Owner. Where factory start-up is not specified for a particular piece of equipment or system, the Contractor shall be responsible to perform start-up. All information shall be completed by the Contractor and submitted to the Owner/Engineer prior to acceptance of the equipment.
- 34.5 The Contractor shall be responsible for completion of System Verification Checklists/Manufacturer's Checklists. Factory startup is required for all HVAC equipment noted. Unless noted otherwise, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists. This shall include the following:
- Heat Pumps (Use the attached forms – no exceptions)
  - Packaged Outside Air Units (Use the attached forms – no exceptions)
  - Variable Frequency Drives
  - Ductless Split Systems
- 34.6 Except for the specific equipment specified in this Specification Section, the manufacturer's recommended startup procedures and checklists will be acceptable for use in the project. Where "manufacturer" startup is not specified, then this Contractor shall perform startup services in strict accordance with manufacturer's instructions. All startup/verification process shall be thoroughly documented by the Contractor and shall include the time and date when performed.
- 34.7 The Contractor shall "zip-tie" a start-up report to each piece of equipment in a clear plastic cover. Once start-up completion is verified by the Engineer the Contractor shall remove all reports and consolidate them into close-out documentation. The Contractor

shall be responsible for completion of System Verification Checklist (SVC) / Manufacturer's Checklists.

**PART 35 – INSPECTION, APPROVALS AND TESTS:**

- 35.1 Before requesting a final review of the installation from the Architect and/or Engineer, each Contractor shall thoroughly inspect their installations to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineer for unnecessary and undue work on their part.
- 35.2 The Contractor shall provide as a part of this Contract any required Agency inspection, licensed and qualified to provide such services. All costs incidental to the provisions of inspections shall be borne by the Contractor.
- 35.3 The Contractor shall advise each Inspecting Agency in writing, with an informational copy of the correspondence to the Architect and/or Engineer, when they anticipate commencing the work. Inspections shall be scheduled for rough-in as well as finished work. The rough-in inspections shall be divided into as many inspections as may be necessary to cover all rough-in without fail. Failure of the Inspecting Agency to inspect the work in a timely manner and submit the related reports may result in the Contractor having to expose concealed work not so inspected. Such exposure will be at the expense of the responsible Contractor.
- 35.4 Approval by an Agency Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these Plans and Specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.
- 35.5 Before final acceptance, the Contractor shall furnish the original and three (3) copies of the certificates of final approval by the Agency Inspector to the Engineer with one copy of each to the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.

**PART 36 - ABOVE-CEILING AND FINAL PUNCH LISTS:**

- 36.1 The Contractor shall review each area and prepare and complete their own punch list for each of the subcontractors as required for the Project Schedule.
- 36.2 Seven (7) days notice shall be given to the Engineer for review of above ceiling work that will be concealed by tile or other materials. Seven (7) days notice shall be given to the Engineer for review of below ceiling work and final inspection.
- 36.3 When all work from the Contractor's punch list is complete at each of the major Project Stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing seven (7) days prior to the proposed date. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings

being installed and at the final punch list review. The Contractor's representative may be requested at the inspections.

- 36.4 If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor by check or money order (due net 10 days from date of each additional visit) at a rate of \$125.00 per hour plus travel expense for extra trips required to complete either of the above ceiling, below ceiling or final punch lists.

**PART 37 – OPERATING INSTRUCTIONS:**

- 37.1 Upon completion of all work and all tests, each Contractor shall furnish the necessary skilled labor and helpers for operating the systems and equipment for a period of three (3) days of eight (8) hours each, or as otherwise specified. Refer to Section HVAC EQUIPMENT for additional requirements. During this period, instruct the Owner or their representatives fully in the operations, adjustment, and maintenance of all equipment furnished. Give at least seven (7) days written notice to the Owner, Architect and Engineer in advance of this training period. The Engineer may attend any such training sessions or operational demonstrations. The Contractor shall certify in writing to the Engineer that such demonstrations have taken place, noting the date, time and names of the Owner's representatives that were present.
- 37.2 Each Contractor shall furnish three complete bound sets for approval to the Engineer instructions for operating and maintaining all systems and equipment included in this contract. All instructions shall be submitted in draft form, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions. Refer to Specification Section SHOP DRAWINGS for additional detail.
- 37.3 Each Contractor, in the above-mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this contract and a detailed, easy to read parts list and the name and address of the nearest source of supply.

**PART 38 – RECORD DRAWINGS:**

- 38.1 The Contractor shall insure that any deviations from the Design are as they occur recorded in red, erasable pencil on record drawings kept at the jobsite. The Engineer shall review the record documents from time to time to insure compliance with this specification. Compliance shall be a contingency of final payment. Pay particular attention to the location of under floor sanitary and water lines, shut-off valves, cleanouts and other appurtenances important to the maintenance and operation of Mechanical Systems. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose and deliver to the Engineer upon completion of the work.
- 38.2 All underground utilities/piping installed as part of this project shall be surveyed by a land surveyor licensed in the State in which the project is being constructed. This shall include underground geothermal piping mains, vaults and vertical bore locations. The survey shall include actual pipe depths to top of pipe every 100 feet in length. The

survey shall also include benchmarks dimensions relative to above grade, fixed structures. The survey shall be furnished on a compact disc in AutoCad “.dwg” format and “.pdf” format. The survey information shall be included in the closeout documentation.

**END OF SECTION**

## **SECTION 20 02 00**

### **SCOPE OF THE MECHANICAL WORK**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS – MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 The Mechanical work for this Contract shall include all labor, materials, equipment, fixtures, excavation, backfill and related items required to completely install, test, place in service and deliver to the Owner the complete mechanical systems in accordance with the accompanying plans and all provisions of these specifications. This work shall primarily include, but is not necessarily limited to the following paragraphs.
- 1.3 All applicable services and work specified in GENERAL PROVISIONS - MECHANICAL.
- 1.4 Installation of all equipment per the manufacturer's instruction, whether specifically detailed or not.
- 1.5 Provide all required motor starters, etc. not provided under the electrical sections.
- 1.6 Thorough instruction of the Owner's maintenance personnel in the operation and maintenance of all mechanical equipment.
- 1.7 Thorough coordination of the installation of all piping, ductwork, equipment and any other material with other trades to insure no conflict in installation.
- 1.8 Approved supervision of the mechanical work.
- 1.9 Procurement of all required inspections, including fees for all inspection services and submission of final certificates of inspection to the Engineers.
- 1.10 Excavation, backfilling, cutting, patching, sleeving, concrete work, etc., required to construct the mechanical systems.
- 1.11 Equipment and controls start-up, verification and documentation as specified.
- 1.12 Record drawings, final inspection certificates, test results, O & M documentation, warranty certification, spare parts and other specified closeout documentation.
- 1.13 Required schedule of values breakdown.
- 1.14 Pipe, duct and equipment identifications.
- 1.15 Preinstallation meetings and equipment mockups.

- 1.16 Complete domestic water service to 5'-0" beyond building footprint. Refer to Civil Drawings/Specifications for additional requirements.
- 1.17 Complete sanitary sewer service to 5'-0" beyond building footprint. Refer to Civil Drawings/Specifications for additional requirements.
- 1.18 Complete fire protection service to 5'-0" beyond building footprint. Refer to Civil Drawings/Specifications for additional requirements.
- 1.19 Complete natural gas service to 5'-0" beyond building footprint. Refer to Civil Drawings/Specifications for additional requirements.
- 1.20 Complete interior and exterior geothermal system and required test results.
- 1.21 Domestic hot, cold and recirculating hot water system.
- 1.22 Soil, waste and vent systems.
- 1.23 All plumbing equipment, fixtures and fittings.
- 1.24 100% automatic sprinkler systems.
- 1.25 Complete heating, ventilation and air conditioning systems.
- 1.26 All mechanical exhaust systems.
- 1.27 All insulation associated with mechanical systems.
- 1.28 Condensate drainage systems.
- 1.29 All required pressure testing, flushing, purging, pressure and flow testing requirements.
- 1.30 Final coordination and connection of all mechanical equipment furnished by others (e.g., kitchen equipment, appliances).
- 1.31 Complete natural gas piping systems.
- 1.32 All required controls, including self checkout and commissioning.

**END OF SECTION**

## **SECTION 20 03 00**

### **SHOP DRAWINGS, MAINTENANCE MANUALS AND PARTS LISTS**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS – MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall prepare and submit to the Engineer, through the Prime Contractor and the Architect within thirty (30) days after the date of the Contract, required copies of all shop drawings, certified equipment drawings, installation, operating and maintenance instructions, samples, wiring diagrams, etc. on all items of equipment specified hereinafter. Refer to Division 1 requirements for shop drawing submittal requirements.
- 1.3 Provide all shops in electronic/PDF format. The Engineer's comments will be returned in electronic format.
- 1.4 Each shop drawing and/or manufacturers descriptive literature shall have the proper notation indicated on it selecting equipment, accessories and features and shall be clearly referenced to the specifications, schedules, fixture numbers, etc., so that the Engineer may readily determine what the Contractor proposes to furnish. All data and information schedules indicated or specified shall be noted on each copy of each submittal.
- 1.5 Submittal data shall include specification data including metal gauges, finishes, accessories, etc. Also, the submittal data shall include certified performance data, wiring diagrams, dimensional data, and a spare parts list. Submittal data shall be reviewed by the Engineer before any equipment or materials is ordered or any work is begun in the area requiring the equipment.
- 1.6 All submittal data shall have the stamp of approval of the Contractor submitting the data as well as the Prime Contractor and the Architect to show that the drawings have been reviewed by the Contractor. Any drawings submitted without these stamps of approval may not be considered and will be returned for proper resubmission.
- 1.7 The Contractor shall make any corrections or changes required by the Engineer and shall re-submit for final review as outlined above.
- 1.8 It shall be noted that review of shop drawings by the Engineer applies only to conformance with the design concept of the project and general compliance with the information given in the Contract Documents. In all cases, the Contractor alone shall be responsible for furnishing the proper quantity of equipment and/or materials required, for seeing that all equipment fits the available space in a satisfactory manner and that piping, electrical and all other connections are suitably located. The Contractor shall also coordinate piping side connections.

- 1.9 The Engineer's review of shop drawings, schedules or other required submittal data shall not relieve the Contractor from responsibility for adaptability of the item to the project; compliance with applicable codes, rules, regulations and information that pertains to fabrication and installation; dimensions, weight and quantities; electrical characteristics; and coordination of the work with all other trades involved in this project.
- 1.10 Prior to ordering any materials or rough-in of any kind, the Mechanical Contractor shall be responsible for final coordination of all electrical requirements (i.e. voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, Prime Contractor, Mechanical Contractor, Electrical Contractor and their sub-contractors.
- 1.11 Equipment shall not be ordered and no final rough-in connections, etc., shall be accomplished until reviewed equipment shop drawings are in the hands of the Contractor. It shall be the Contractor's responsibility to obtain reviewed shop drawings and to make all connections, etc. in the neatest and most workmanlike manner possible. The Contractor shall coordinate with all the other trades having any connections, roughing-in, etc. to the equipment.
- 1.12 If the Contractor fails to comply with the requirements set forth above, the Engineer shall have the option of selecting any or all items listed in the Specifications or on the Drawings; and the Contractor shall be required to furnish all materials in accordance with this list.
- 1.13 Colors for equipment in other than mechanical spaces shall be selected from the Manufacturer's standard and factory optional colors unless noted otherwise on the Plans. Color samples shall be furnished with the shop drawing submission for such equipment.
- 1.14 All submittals for mechanical equipment shall include all information specified and scheduled. This shall include air and water pressure drops, RPM, noise data, face velocities, horsepower, voltage motor type, steel or aluminum construction, and all accessories clearly marked.
- 1.15 All items listed in the schedules shall be submitted for review in a tabular form similar to the equipment schedule. All items submitted shall be designated with the same identifying tag as specified on each sheet.
- 1.16 Any submittals received in an unorganized manner without options to be provided specifically noted and with incomplete data will be returned for resubmittal.

**PART 2 – SHOP DRAWINGS:**

- 2.1 Shop Drawings, descriptive literature, technical data and required schedules shall be submitted on the following:

Access Doors  
Air Filtration & Components  
Chemical Treatment and Test Reports  
Ductless Split Systems (2.2.1)  
Ductwork Accessories/Volume Dampers  
General Exhaust Fans (2.2.1)  
Fire Protection Sprinkler System (2.2.3)  
Firestopping (2.2.4)  
Floor Drains  
Geothermal Piping, Specialties  
Heat Pump Units (2.2.1)  
Ductwork & Fittings  
Insulation  
Packaged Outside Air Handling Units (2.2.1)  
Plumbing Fixtures, Fittings and Trim (2.2.1)  
Plumbing Specialties  
Pumps and Hydronic Specialties (2.2.1)  
Register, Grilles, Diffusers and Louvers  
Temperature Controls & Components (2.2.1 & 2.2.2)  
Valves  
Variable Frequency Drives(2.2.1)  
Air Flow Dampers (2.2.1)  
Water Heaters (2.2.1)

(Refer to the corresponding Special Notes.)

2.2 **SPECIAL NOTES:**

- 2.2.1 For all items above, upon substantial completion of the project, the Contractor shall deliver to the Engineer (in addition to the required Shop Drawings) three (3) complete copies of operation and maintenance instructions and parts lists for each item above. Where available, documents shall include at least:
- Detailed operating instructions
  - Detailed maintenance instructions including preventive maintenance schedules.
  - Addresses and phone numbers indicating where parts may be purchased.
  - Expanded parts drawings, parts lists, service manuals, schematics, wiring diagrams.
  - Master air filter list including equipment identification, filter size, filter quantity, and supplier contact information.
  - Start-up reports, service records and test reports.
- 2.2.2 Shop drawings for the Temperature Control Systems shall include detailed, scaled plans and schematic diagrams indicating the function and operation of the system. Refer to Specification Section – CONTROLS for additional requirements.

- 2.2.3 Shop drawings for the Building Fire Protection System shall be prepared and stamped by a Certified Contractor and shall meet the criteria of the authority having jurisdiction and submitted to the Engineer. After the Engineer's review, they shall be submitted by the Contractor to the proper state authorities along with the required agency review fee. Refer to Specification Section – FIRE PROTECTION for additional requirements.

**END OF SECTION**

## **SECTION 20 11 00**

### **SLEEVING, CUTTING, PATCHING, REPAIRING AND FIRESTOPPING**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS – MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall be responsible for all openings, sleeves, trenches, etc., that may be required in floors, roofs, ceilings, walls, etc., and shall coordinate all such work with the General Contractor and all other trades. Coordinate with the General Contractor, any openings which they are to provide before submitting a bid proposal in order to avoid conflict and disagreement during construction. Improperly located openings shall be reworked at the expense of the Contractor.
- 1.3 The Contractor shall plan their work ahead and shall place sleeves, frames or forms through all walls, floors and ceilings during the initial construction, where it is necessary for piping, ductwork, conduit, etc., to route through; however, when this is not coordinated, the Contractor shall then do all cutting and patching required for the installation of their work, or pay other trades for doing this work when so directed by the Engineer. Any damage caused to the building by this Contractor shall be corrected or rectified at their expense.
- 1.4 The Contractor shall notify other trades in due time where they will require openings or chases in new concrete, masonry, etc. Set all concrete inserts and sleeves for their work. Failing to coordinate, Contractor shall cut openings for the work and patch same as required at their expense with qualified tradesman.
- 1.5 The Contractor shall be responsible for properly shoring, bracing, supporting, etc., any existing and/or new construction to guard against cracking, settling, collapsing, displacing or weakening while openings are being made. Any damage occurring to the existing and/or new structures, due to failure to exercise proper precautions or due to action of the elements shall be promptly and properly corrected to the satisfaction of the Engineer.
- 1.6 All work improperly performed or not performed as required in this section, shall be corrected by the General Contractor at the responsible Contractor's expense.

#### **PART 2 – SLEEVES:**

- 2.1 Cast iron or Schedule 40 steel sleeves shall be installed through all walls where pipe enters the building below grade. Sleeves shall be flush with each face of the wall and shall be sufficiently larger than the entering pipe to permit thorough caulking between pipe and sleeve for water proofing.

- 2.2 Horizontal sleeves passing through exterior walls or where there is a possibility of water leakage and damage shall be caulked watertight. Utilize "Link-Seal" at these locations.
- 2.3 In all cases, sleeves shall be at least two pipe sizes larger than nominal pipe diameter plus insulation.
- 2.4 Sleeves through walls and floors shall be cut off flush with inside surface unless otherwise indicated.
- 2.5 Vertical sleeves in roofs shall be flashed and counter flashed with lead (4 lb.) or 16 oz. copper and welded or soldered to piping, lapped over sleeve and properly weather sealed. Where sleeves pass through roof construction, sleeves shall extend minimum of 12" above the roof.

**PART 3 – CUTTING:**

- 3.1 All openings in plaster, gypsum board or similar materials, shall be framed by means of plaster frames, casing beads, or angle members as required. The intent of this requirement is to provide smooth, even termination of wall, floor and ceiling finishes as well as to provide a fastening means for devices, etc.
- 3.2 The Mechanical Contractor shall coordinate all openings in masonry walls with the General Contractor; and, unless otherwise indicated in the Contract Documents, shall provide lintels for all openings required for the mechanical work such as louvers, exhaust fans, etc. Prime paint all lintels. Lintels shall be sized as follows:
  - 3.2.1 New Openings under 48" in width: Provide one 3½"x3½"x3/8" steel angle for each 4" of masonry width. Lintel shall have 8" bearing on each end.
  - 3.2.2 New Openings over 48" in width: Consult with Structural Engineer.
- 3.3 No cutting shall be performed at location that will weaken the structure and unnecessary cutting must be avoided. If in doubt, contact the Engineer.
- 3.4 Pipe openings in slabs and walls shall be cut with core drill. Hammer devices will not be permitted. Edges of trenches and large openings shall be scribe-cut with a masonry saw.

**PART 4 – PATCHING, REPAIRING AND FINISHING:**

- 4.1 Patching and repairing made necessary by work performed under this Division shall be included as a part of the work and shall be done by skilled workers of the trade. The work shall be performed in strict accordance with the provisions herein before specified to match adjacent surfaces and in a manner acceptable to the Engineer.
- 4.2 Where portions of existing sites, lawns, shrubs, paving, etc. are disturbed for installation of work of this Division, such items shall be repaired and/or replaced back to original or better condition to the satisfaction of the Engineer.
- 4.3 Piping and ductwork passing through floors, ceilings and walls in finished areas shall be

fitted with chrome plated brass escutcheon trim pieces of sufficient outside diameter to amply cover the sleeved openings and an inside diameter to closely fit the pipe/duct around which it is installed.

- 4.4 Flanged metal collars shall be provided around all ducts, flues, pipes, etc. at all wall penetrations; both sides. Penetrations through any wall will require the installation of flanged collars. Openings shall not be any larger than 2" in any direction than the piping/duct passing through the wall. Openings larger than this requirement shall also be infilled to match adjacent construction. Fill void with insulation for sound reduction.

#### **PART 5 – FIRESTOPPING:**

- 5.1 Provide shop drawings indicating penetration detail for each type of wall and floor construction. Shop drawings must be specific for each individual type of penetration (one-hour fire rated gypsum wall board with insulated metal pipe penetration, etc.) Provide copies to the authority having jurisdiction if required.
- 5.2 All mechanical pipes and ducts penetrating fire rated floors and walls shall be firestopped by this Contractor. All firestopping products and assemblies installed shall be UL listed.
- 5.3 Where the installation of conduit, ducts, piping, etc. requires the penetration of fire or smoke rated walls, ceilings or floors, the space around such conduit, duct, pipe, etc., shall be tightly filled with an approved non-combustible fire insulating material and properly sealed to maintain the rating integrity of the wall, floor or ceilings affected.
- 5.4 Where the installation of ductwork requires the penetration of non-rated floors, the space around the duct or pipe shall be tightly filled with an approved non-combustible material.
- 5.5 The manufacturer of the firestopping materials shall provide on site training for the installing Contractor. The training session shall demonstrate to the Contractor the proper installation techniques for all the firestopping materials.
- 5.6 Firestopping materials include (but are not limited to) wraps, strips, caulks, moldable putties, restricting collars with steel hose clamps, damming materials, composite sheets, fire dam caulks, steel sleeves, etc.
- 5.7 The following indicates the 3M penetration details for uninsulated pipe penetration of various wall and floor construction types (the list is not inclusive):
- One, two- or three-hour fire rated concrete floor - 3M #5300-MPC8.
  - One, two- or three-hour fire rated solid or block concrete wall - 3M #5300-MPC16 or 3M #5300-MPC26.
  - One-hour fire rated gypsum wallboard - 3M #5300-MPC7.
  - Two-hour fire rated gypsum wallboard - 3M #5300-MPC7.
- 5.8 The following indicates the 3M penetration details for insulated pipe penetrations of various wall and floor construction types (the list is not inclusive):
- One, two- and three-hour fire rated concrete floor - 3M #5300-IMP2.
  - One, two- and three-hour concrete block wall - 3M #5300-IMP2.

- One-hour fire rated gypsum wallboard - 3M #5300-IMP4.
  - Two-hour fire rated gypsum wallboard - 3M #IMP7.
- 5.9 HVAC ducts penetrating a one- or two-hour fire rated wall or floor shall be firestopped per 3M #5300-HVD1.
- 5.10 Multiple pipes penetrating fire rated floors and walls may be firestopped as a group. Submit details for specific applications if this method of firestopping is chosen.

**END OF SECTION**

## **SECTION 20 12 00**

### **EXCAVATION, TRENCHING, BACKFILLING AND GRADING**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall include all excavating, filling, grading, and related items required to complete their work as shown on the drawings and specified herein or as required to complete, connect and place all mechanical systems in satisfactory operation.

#### **PART 2 – EARTHWORK CLASSIFICATION:**

- 2.1 Without regard to the materials encountered, all excavation and materials excavated shall be unclassified. Materials to be excavated shall include earth, rock, concrete or any other obstructions encountered in excavation and/or trenching to install underground utility pipes, tanks, vaults or other equipment.
- 2.2 Include all costs for rock removal, including mass rock and trench rock in the bids. No adjustment in the contract sum will be made on account of the presence or absence of rock, shale, debris, obstructions or other materials encountered in the excavating. The Contractor shall be responsible for the removal of all materials encountered as required for the installation of the work.
- 2.3 It shall be distinctly understood that references to rock, earth, topsoil or any other excavated or non-excavated material or other material on the construction plans, cross section, contract documents, technical specification or provisions, whether in numbers, words, letters, lines or graphically shown, is solely for information for the Engineer and Owner. This information shall not be taken as an indication of the classification of the material to be excavated, bored or removed by any method, including drilling and blasting, or materials not removed. This information shall not be taken as to the quantity of either rock, earth, topsoil, or any other material involved, or the quality of the material such as hardness, wetness, workability or suitability of the material either during excavation and construction or as a material to be reused during construction.
- 2.4 The Contractor shall draw their own conclusions as to the surface and sub-surface conditions to be encountered during construction of this project. The Engineer and Owner do not give any guarantee or warranty as to the accuracy of the data shown and no claim will be considered for additional compensation when the materials encountered are not in accord with the information shown.
- 2.5 Refer to Specification Division EARTHWORK located in the Site Work portions of the Specifications and Civil Drawings for additional information. Also refer to the

GEOTECHNICAL report (provide for informational purposes only) included in the Front End of the Specifications.

**PART 3 – EXCAVATION:**

- 3.1 Unless otherwise shown or required, provide separate trenches for sewers, water lines and other underground raceways, with a minimum of 10 feet measured from outside diameter between pipes. In locations, such as close to buildings where separate trenches for sewers and water lines are impractical, lay the water pipe on a solid shelf at least 2'-0" above the top of the sewer and 2'-0" to the side.
- 3.2 Water lines crossing under sewer lines, or crossing less than 2 feet above sewer lines, must be concrete encased for a distance not less than 5 feet on either side of the point of crossover.
- 3.3 Excavate trenches of sufficient width for proper installation of the work. Excavate to 6" below the bottom of new pipes for installation of compacted fill.
- 3.4 Sheet and brace trenches as necessary to protect workers and adjacent structures. Comply with local regulations or, in the absence thereof, with the latest version of "Manual of Accident Prevention in Construction" by the Associated General Contractors of America and current OSHA Standards. Do not remove sheeting until trench is backfilled sufficiently to protect pipe and/or equipment and prevent injurious caving. Where removal of sheeting and/or bracing is hazardous, leave in place. Cut off such sheeting not to be removed at least 3 feet below finished grade.
- 3.5 Rules and regulations governing the respective utilities shall be observed in executing all work under this Division. Active utilities discovered in the course of excavation shall be protected or relocated in accordance with written instructions from the Engineer. Inactive and abandoned utilities encountered in trenching operations shall be removed and abandoned with ends plugged or capped in accord with current codes and safe practice. If in doubt, contact Engineer.
- 3.6 Machine excavation shall not be allowed within ten (10) feet of electric lines, natural gas lines or other lines carrying combustible materials. Use only hand tool excavation methods.
- 3.7 The removal of rock shall be accomplished by use of hand or power tools only. Blasting shall not be permitted. Any damage to existing structures, piping services, or rock intended for bearing, shall be corrected at the responsible Contractor's expense.
- 3.8 Perform final grading of trench bottoms by hand tools; carry machine excavation only to such depth that soil bearing for pipes and raceways will not be disturbed. Grade the bottom of trenches evenly to insure uniform bearing for all piping and raceways. Cut bell holes as necessary for joints and joint-making. Except as hereinafter specified, bottom of trenches for bell and spigot pipe, flanged pipe, etc. shall be shaped to the lower quadrant of pipe with additional excavation for bell or flange. Piping installed where it rests on bell or flange and/or is supported with blocks or wedges will not be accepted.

- 3.9 Keep trenches free from water while construction is in progress. Under no circumstances lay pipe or appurtenances in water. Pump or bail water from bell holes to permit proper joining of pipe. Any dewatering from this Contractor's trenches which is required during construction, shall be included in this Contract.
- 3.10 In no case shall excavation work be accomplished that will damage in any way the new structure, existing structures, equipment, utility lines, landscaping to remain, etc. The Contractor shall take the necessary steps to prevent flow of eroded earth by water or landslide onto the property of others, or against the structures. The repair of all such damage or any other damage incurred in the course of excavation shall be at the responsible Contractor's expense.
- 3.11 Use surveyor's level to establish elevations and grades.
- 3.12 Machine excavation shall be held a sufficient distance from foundations and footings to insure no damage to same. Contractor shall accept full responsibility and pay for repairs and/or replacement of structural members, footings, etc.
- 3.13 The Contractor shall accept the site as it is. Remove all trash, rubbish and unsuitable material from the site at the completion of excavation work.
- 3.14 The Contractor shall provide and maintain barricades, trench plates and temporary bridges around excavations as required for safety. Temporary plates or bridges shall be provided where excavations cross paved areas and walks. The Contractor shall maintain these plates and bridges in a safe and passable condition for all traffic until removal. Refer to OSHA Standards for such installations and comply with same in all details.
- 3.15 Pay particular attention to existing utilities and lines to avoid damage. The locations of existing lines which are indicated on the plans were taken unconfirmed from drawings prepared for previous construction and locations are approximate only. Also, certain water, gas, electric, storm and sanitary sewer lines and other underground appurtenances, active or abandoned, may not appear on the drawings. It shall be each Contractor's responsibility to ascertain the location of all lines and excavate with caution in their area.
- 3.16 Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Engineer. Unauthorized excavation, as well as remedial work directed by Engineer, shall be at Contractor's expense.
- 3.17 Maintain carefully all bench marks, monuments and other reference points. If disturbed or destroyed, replace as directed.

**PART 4 – BACKFILL, COMPACTION AND SURFACE REPAIR:**

- 4.1 Backfilling for Mechanical Work shall include all trenches, manhole pits, tanks and/or any other earth and/or rock openings which are excavated under this Contract. Backfilling shall be carefully performed and the surface restored to its original level to receive new finish. Wherever trenches and earth openings have not been properly filled and/or

settlement occurs, they shall be re-excavated, re-filled and properly compacted, smoothed off and finally made to conform to the level of the original ground surface.

- 4.2 All trenches shall be backfilled with a bedding of 6" of manufactured sand or #8 crushed stone after finished excavation. Install the new pipe on the compacted fill material. Install tracer wire on all pipe. Apply any special coatings to the pipe. Also perform all required pressure tests and check the grade of the pipe to ensure that it is correct and free of swags, bows or bends. Once coatings and testing are complete, backfill the pipe bed to 12" above the top of the pipe with specified compacted fill material. Backfill the remainder of the trench with earth (rock and debris free) tamped at 6" intervals. Water settling of backfill is permitted only as an aid to mechanical compacting.
- 4.3 Backfill and compact beneath areas to be seeded or sodded within six (6) inches of finished grade. The remaining six (6) inches shall be backfilled with clean top soil.
- 4.4 Backfill and compact beneath concrete slabs, paved areas, walks, etc. shall be brought to proper grade to receive the sub-base and paving. No concrete or paving shall be placed on uncompacted fill or unstable soil.
- 4.5 Wherever, in the opinion of the Engineer, the soil at or below the requisite pipe grade is unsuitable for supporting piping, special support shall be provided as directed by the Engineer.
- 4.6 Backfill and compaction for natural gas lines shall be in strict accordance with the local utility company or local municipality's requirements. If in doubt, contact the utility company or local municipality.
- 4.7 Unsuitable material and surplus excavated material not required for backfill shall be removed from the site. The location of dump and length of haul shall be the affected Contractor's responsibility.
- 4.8 Provide and place any additional fill material from off the site as may be required for backfill. Fill obtained from offsite shall be of kind and quality as specified for backfill and the source approved by the Engineer and shall be brought to the site by the Contractor requiring the fill.
- 4.9 If not specified or indicated elsewhere in the Contract Documents to be performed by Others, the Contractor shall lay new sod over their excavation work for existing disturbed grassy areas. Level, with adjacent surface, compact and water in accord with sound sodding practice.
- 4.10 Control soil compaction during construction providing minimum percentage of density specified for each area classification indicated in the following two paragraphs.
- 4.11 At a minimum, fill in grass areas shall be compacted to 90% Standard Proctor Density, ASTM D-698, at moisture content between 2 percent below to a 3 percent above the optimum moisture content or as specified in Specification Division EARTHWORK; whichever is most stringent.

- 4.12 At a minimum, fill in concrete or asphalt area shall compacted to 98% Standard Proctor Density, ASTM D-698, at moisture content between 2 percent below to a 3 percent above the optimum moisture content or as specified in Specification Division EARTHWORK; whichever is most stringent.
- 4.13 Place backfill and fill materials evenly adjacent to structures, piping, or conduit to required elevations. Take care to prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.
- 4.14 All materials used for backfill around structures shall be of a quality acceptable to the Engineer and shall be free from large or frozen lumps, large rocks, wood, and other extraneous material. All spaces excavated and not occupied by footings, foundations, walls or other permanent work shall be refilled with earth up to the surface of the surrounding ground, unless otherwise specified, with sufficient allowance for settlement.
- 4.15 In making the fills and terraces around the structures, the fill shall be placed in layers not exceeding 8 inches in depth and shall be kept smooth as the work progresses. Each layer of the fill shall be compacted. Sections of the fill immediately adjacent to buildings or structures shall be thoroughly compacted by means of mechanical tamping or hand tamping as may be required by the conditions encountered. All fills shall be placed so as to load structure symmetrically.
- 4.16 Rough grading shall be held below finished grade and then the topsoil which has been stockpiled shall be evenly spread over the surface. The grading shall be brought to the levels as specified. Final dressing shall be accomplished by hand work or machine work, or a combination of these methods as may be necessary to produce a uniform and smooth finish to all parts of the regrade. The surface shall be free from clods greater than one inch in diameter. Excavated rock (1" and smaller) may be placed in the fills, but is shall be thoroughly covered. Rock placed in fills shall not be closer than 24 inches from finished grade. Refer to Specification Division EARTHWORK.
- 4.17 Maintenance Settling: Where settling is measurable or observable at excavated areas during Project Warranty Period, remove surface (pavement, concrete or any other surface or finish), add backfill material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent work, and eliminate evidence of restoration.
- 4.18 Disposal of Excess Non-organic Soil and Rock: Any excess excavated waste material shall become the property of the Contractor and shall be disposed of by the Contractor off site at no additional cost to the Owner.
- 4.19 Unless otherwise directed by the Owner during construction, excess topsoil and subsoil suitable for fill shall be disposed of by the Contractor off site at no additional cost to the Owner.

**PART 5 – MINIMUM DEPTHS OF BURY TO TOP OF PIPE:**

5.1 In the absence of other indication, the following shall be the minimum depth of bury to top of pipe of exterior utility lines. Check drawings for variations.

5.1.1	Geothermal Lines	48 inches below final grade.
5.1.2	Domestic Water Lines	Refer to Civil drawings for requirements.
5.1.3	Fire Service Lines	Refer to Civil drawings for requirements.
5.1.4	Storm Lines	Refer to Civil drawings for requirements.
5.1.5	Sanitary Lines	Refer to Civil drawings for requirements.
5.1.6	Natural Gas Lines	Refer to Civil drawings for requirements.
5.1.7	All Other Lines Not Listed	36 inches below final grade.

**END OF SECTION**

## **SECTION 20 13 00**

### **PIPE, PIPE FITTINGS AND PIPE SUPPORT**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 Each Contractor's attention is also directed to Specification Section HANGERS, CLAMPS, ATTACHMENTS, ETC.
- 1.3 Unless otherwise indicated, all materials shall be new and of the best grade and quality for the type specified. Materials shall comply with the "Buy American Act".
- 1.4 Where piping is not indicated on the plans, but is obviously or apparently required, contact the Engineer prior to submission of the bid.
- 1.5 All piping shall be capped or plugged during erection as required to keep clean and debris and moisture free.
- 1.6 The piping indicated shall be installed complete and shall be of the size indicated. When a pipe size is not indicated, the Contractor shall request the pipe size from the Engineer. Where a section of piping is not indicated but is obviously required for completion of the system, the Contractor shall provide same at no additional cost to the project.
- 1.7 All piping shall be installed straight and true, parallel or perpendicular to the building construction. Piping shall be installed so as to allow for expansion without damage to the building finishes, structure, pipe, equipment, etc., use offsets, U-bends or expansion joints as required. No mitered joints or field fabricated pipe bends shall be accepted. Pipe shall clear all windows, doors, louvers and other building openings.
- 1.8 All pipes shall be supported in a neat and workmanlike manner and wherever possible, parallel runs of horizontal piping shall be grouped together on hangers. Vertical risers shall be supported at each floor line with approved steel pipe riser clamps. Spacing of pipe supports shall not exceed eight (8) foot intervals for pipes 3" and smaller and ten (10) foot intervals on all other piping. Small vertical pipes (1" and less) shall be bracketed to walls, structural members, etc. at four (4) foot intervals so as to prevent vibration or damage by occupants.
- 1.9 Insulated piping shall be supported on a rigid insulation block at each hanger so as to prevent crushing of insulation by hangers. Hangers shall pass completely around the insulation jacket and a steel protective saddle shall be applied to prevent compression of the insulation. Refer to Specification Section INSULATION - MECHANICAL.

- 1.10 The use of wire or perforated metal to support pipes will not be permitted. Hanging pipes from other pipes shall not be permitted.
- 1.11 In metal buildings or buildings with light gauge trusses, support piping with standard pipe hangers with C-clamp connection to main structural members (not perlines), use angle steel cross pieces between main structural members where required to provide rigid support.
- 1.12 Where piping rests directly on a hanger, clip, bracket or other means of support, the support element shall be of the same material as the pipe, (e.g., copper to copper, ferrous to ferrous, etc.) or shall be electrically isolated one from the other so as to prevent pipe damage by electrolysis. Pay particular attention and do not allow copper pipe to rest on ferrous structural members, equipment, etc. without electrolytic isolation. This includes temporary support required during Construction.
- 1.13 In general, piping shall be installed concealed except in mechanical rooms, etc. unless otherwise indicated, and shall be installed underground or beneath concrete slabs only where indicated. All lines at ceilings shall be held as high as possible and shall run so as to avoid conflicts with other trades, and to facilitate the Owner's use and maintenance. Location of pipe in interior partitions shall be carefully coordinated with whoever will construct the partitions after the piping is in place. Where exposed risers occur, they shall be kept as close to walls as possible.
- 1.14 Pipe shall be cut accurately to measurements established at the building by the Contractor and worked into place without springing or forcing. All pipes shall be reamed to full pipe diameter before joining and before assembling. All lengths of pipe shall be set vertically and tapped with a hammer to remove scale and dust and inspected to ensure that no foreign matter is lodged therein.
- 1.15 All hot and cold-water piping shall be kept a sufficient distance apart so as to prevent heat transfer between them. Cold water piping shall also be kept apart from refrigerant hot gas lines.
- 1.16 Piping carrying water or other fluids subject to freezing shall not be installed in locations subject to freezing. If in doubt, consult Engineer.
- 1.17 Pay particular attention to conflict of piping with other work. Do not install until conflict is resolved. If in doubt, consult Engineer.
- 1.18 Piping materials in each system shall, to the extent practicable, be of the same material. Frequent changes of material (for example, from copper to steel) shall be avoided and in no case shall be accomplished without use of insulating unions and permission of the Engineers.
- 1.19 Dielectric couplings or through ways shall be provided at all connections of dissimilar materials. No dielectric unions are allowed.
- 1.20 Nipples shall be of the same material, composition and weight classification as pipe with which installed.

- 1.21 Apply approved pipe dope for service intended to all male threaded joints. The dope shall be listed for intended use.
- 1.22 Eccentric reducers shall be used where required to permit proper drainage and venting of pipe lines; bushings shall not be permitted.
- 1.23 High points of geothermal systems shall have manual air vents as required unless automatic air vents are specifically indicated. Pipe to suitable drainage point.
- 1.24 Installation of pipe shall be in such a manner as to provide complete drainage of the system, whether detailed or not on plans. Drain valves shall be provided at all drainage points on pipes. Drain valves shall be ½" size ball valves with ¾" hose thread end and vacuum breaker. Label each drain valve.
- 1.25 Where plastic piping penetrates a fire rated assembly, it shall be replaced with a threaded metal adapter and metal pipe or whatever means necessary to maintain the separation rating in accordance with local plumbing and fire codes.
- 1.26 Plastic piping or any material with a flame and smoke spread rating not approved for plenum use shall not be permitted in supply, return, relief or exhaust plenums.
- 1.27 All increases in vent size at roof shall be by means of service weight cast iron increasers.
- 1.28 Non-metallic piping shall be installed in strict accordance with the manufacturer's instructions. If no such instructions are available, consult Engineer.
- 1.29 When running any type of pipe below a footing, perpendicular to the footing, the area underneath the footing and in the zone of influence shall be backfilled with concrete. The zone of influence is the area within a 45-degree angle projecting down from the top edge of footing on all sides of the footing.
- 1.30 When running any type of pipe below a footing, parallel to the footing, the area underneath the zone of influence shall be backfilled with 4" of crushed stone or sand bedding under the pipe. Each pipe section shall be anchored into unexcavated earth on both ends with deadman anchor system. The remainder of the trench in the zone of influence shall be backfilled with cementitious flowable fill. The zone of influence is the area within a 45-degree angle projecting down from the top edge of the footing on all sides of the footing.
- 1.31 Piping for all drainage systems shall be installed to permit flow, trapping, and venting in accord with current codes and best practice.
- 1.32 Install all gas piping per NFPA54. Union or valves shall not be installed in an air plenum. Piping below slab must be sleeved and vented. Piping installed in contained non-vented areas shall not have mechanical joints.

- 1.33 The entire domestic hot, cold and recirculating hot water piping system shall be sterilized in strict accord with requirements of the Department of Health Codes, Rules and Regulations for the State in which the work is being accomplished.
- 1.34 Site water piping utilized for domestic service shall be filled, cleaned and disinfected. Disinfection shall utilize chlorine per the local water company standards or approved equal. Hyper-chlorinated water shall be discharged and diluted at the end of the pipeline into the sanitary sewers per local utility regulations.
- 1.35 The entire sanitary waste and vent piping system within the building shall be air-tight. If any sewer gases are present within the building, it shall be the Contractor's responsibility to locate and correct any leaks and retest as required. Any sewer odor issues that occur during the Warranty Period shall be corrected by the Contractor.
- 1.36 Refrigerant piping must be installed to meet the HVAC equipment manufacturer's requirements. A refrigerant piping schematic shall be obtained from the equipment manufacturer which indicates pipe sizes, valves, traps, sight glasses and other required refrigerant specialties. While installing or soldering refrigerant lines, the piping system must be continuously purged with nitrogen. After the piping system is installed, the refrigerant system must be evacuated to 25 microns for eight hours. Contact Engineer 36 hours prior to installation of refrigerant lines or evacuation of refrigerant system.

#### **PART 2 – UNIONS AND FLANGES:**

- 2.1 Screwed unions, soldered unions or bolted flanges shall be provided as required to permit removal of equipment, valves and piping accessories from the piping system. Keep adequate clearances for coil removal, rodding, tube replacement, motor lubrication, filter replacement, etc. Flanged joints shall be assembled with appropriate flanges, gaskets and bolting. The clearance between flange faces shall be such that the connections can be gasketed and bolted tight without imposing undue strain on the piping system.
- 2.2 Dielectric insulating couplings or though ways shall be used wherever the adjoining materials being connected are of dissimilar metals such as connections between copper and steel pipe. No dielectric unions are allowed.

#### **PART 3 – SPECIFICATIONS STANDARDS:**

- 3.1 All piping and material shall be new, comply with the "Buy American Act" and shall conform to the following minimum applicable standards:
  - Steel pipe; Schedule 40; ASTM A-53.
  - Copper tube; Type K, L, M; ASTM B88-62; Type DWV ASTM B306-62.
  - Welding fittings; ASA B16.9.
  - Cast brass and wrought copper fittings; ASA B16.18.
  - Cast brass drainage fittings; ASA B16.23.
  - PVC pipe; Schedule 40; ASTM D-1785.

**PART 4 – PIPE TESTING:**

- 4.1 Piping shall be tested before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory.
- 4.2 Water piping systems shall be subjected to a hydrostatic test of 150 psi. The system shall be proven tight after a twenty-four (24) hour test.
- 4.3 The house drain line, interior storm sewers, interior rain water conductors, and all soil, waste and vent piping shall be subjected to a hydrostatic test of not less than a 10-foot head or an air test of not less than 5 psi and shall hold for 15 minutes.
- 4.4 Exterior sewer lines to the termination point outside the building shall be subject to a ten-foot hydrostatic test or an approved smoke test. These lines shall be subjected to a second test after 2 feet of backfill has been properly installed.
- 4.5 After fixtures have been installed, the entire plumbing system, exclusive of the house sewer, shall be subjected to an air pressure test equivalent to one inch water column and proven tight. The Contractor responsible shall furnish and install all of the test tees required, including those for isolating any portion of the system for tests.
- 4.6 The Contractor shall perform all additional tests that may be required by the Department of Health or other governing agency.
- 4.7 Any leaks or imperfections found shall be corrected and a new test run until satisfactory results are obtained. The cost of repair or restoration of surfaces damaged by leaks in any system shall be borne by the Contractor.
- 4.8 The natural gas service shall be tested in accordance with requirements and/or recommendations of the local gas company.
- 4.9 Natural gas piping downstream of the meter assembly shall be tested per the local gas company requirements or the following (whichever is stricter):
  - Low Pressure (up to 14" wc) – Test to 10 psi for 24 hours.
  - Elevated Pressure (up to 2 psi) – Test to 50 psi for 24 hours.
  - Medium pressure (up to 60 psi) – Test to 100 psi for 24 hours.

**PART 5 – PITCH OF PIPING:**

- 5.1 All piping systems shall be installed so as to drain to a low point. Certain minimum pitches shall be required for this drainage. For proper flow and/or for proper operation, the following pitches shall be required:
- 5.2 INTERIOR SOIL, WASTE AND VENT PIPING: ¼" per foot in direction of flow where possible but in no case less than 1/8" per foot.
- 5.3 SITE SANITARY LINES: Refer to the Civil Drawings for requirements.

- 5.4 CONDENSATE DRAIN LINES FROM COOLING EQUIPMENT: Not less than ¼" per foot in direction of flow.
- 5.5 ALL OTHER LINES: Provide ample pitch to a low point to allow 100 percent drainage of the system.

**PART 6 – EXTERIOR APPLICATIONS (SITE WORK):**

- 6.1 SITE SANITARY SEWER: Refer to the Civil Plans and Specifications.
- 6.2 SITE STORM SEWER: Refer to the Civil Plans and Specifications.
- 6.3 SITE WATER: Refer to the Civil Plans and Specifications.
- 6.4 SITE FIRE PROTECTION: Refer to the Civil Plans and Specifications.
- 6.5 SITE NATURAL GAS: Refer to the Civil Plans and Specifications.
- 6.6 SITE FIRE PROTECTION: - Refer to the Specification Section – FIRE PROTECTION.

**PART 7 – PLUMBING PIPING APPLICATIONS:**

- 7.1 SOIL, WASTE AND VENT PIPING (BELOW SLAB):
- 7.1.1 Schedule 40 PVC pipe with drainage pattern fittings and solvent cement joints made in accordance with the Plumbing Code. PVC pipe shall not be installed where waste water applications exceed 140 deg F.
- 7.1.2 Piping below slab shall be a minimum of 2" in size.
- 7.2 SOIL, WASTE AND VENT PIPING (ABOVE SLAB):
- 7.2.1 Schedule 40 PVC pipe with drainage pattern fittings and solvent cement joints made in accordance with the Plumbing Code.
- 7.3 DOMESTIC COLD, HOT AND RECIRCULATING HOT WATER PIPING (ABOVE SLAB):
- 7.3.1 All Pipe Sizes: Type "L" hard copper tubing with wrought copper fittings with lead free solder equivalent in performance to 95/5. (Maximum lead content of solder and flux is 2%).
- 7.3.2 Optional 3" and Smaller - "Pex" Domestic Water Piping: Piping shall be PEX-a (Engel-Method Crosslinked Polyethylene) Piping: ASTM F 876/877 by Uponor. PEX-a Fittings: elbows, adapters, couplings, plugs, tees and multi-port tees (1/2 inch through 3-inch nominal pipe size): ASTM F1960 cold-expansion fitting manufactured from the following material types:
- UNS No. C69300 Lead-free (LF) Brass.

- 20% glass-filled polysulfone as specified in ASTM D 6394.
- Unreinforced polysulfone (group 01, class 1, grade 2) as specified in ASTM D 6394.
- Polyphenylsulfone (group 03, class 1, grade 2) as specified in ASTM D 6394.
- Blend of polyphenylsulfone (55-80%) and unreinforced polysulfone (rem.) as specified in ASTM D 6394.
- Reinforcing cold-expansion rings shall be manufactured from the same source as PEX-a piping manufacturer and marked "F1960".

PEX-to-Metal Transition Fittings:

- Manufacturers: Provide fittings from the same manufacturer of the piping.
- Threaded Brass to PEX-a Transition: one-piece brass fitting with male or female threaded adapter and ASTM F 1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring.
- Brass Sweat to PEX-a Transition: one-piece brass fitting with sweat adapter and ASTM F 1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring.
- PEX-a to Flange Transition: two-piece brass fitting with lead-free ProPEX adapter and steel flange conforming to ASME B 16.5.

Store PEX tubing indoors, in cartons or under cover to avoid dirt or foreign material from entering the tubing. Do not expose PEX tubing to direct sunlight for more than six months. If construction delays are encountered, cover the tubing that is exposed to direct sunlight.

PEX piping to be installed in strict accordance with the manufacturer's detailed instructions, installation, fastening, crimping, etc. All PEX piping and fittings to be a clean install.

7.4 DOMESTIC COLD, HOT AND RECIRCULATING HOT WATER PIPING (BELOW SLAB): Pex Tubing, there shall be no joints beneath slabs.

7.5 NATURAL GAS PIPING – INTERIOR:

7.5.1 Schedule 40 black steel pipe with malleable iron threaded fittings for pipe sizes 2" and smaller.

7.5.2 Schedule 40 black steel pipe with wrought steel butt welded fittings for pipe sizes 2½" and larger.

7.5.3 Paint all exterior piping as specified in Section IDENTIFICATIONS, TAGS, CHARTS, ETC.

7.6 WATER HEATER RELIEF LINE: Type "M" copper tubing with sweat fittings and 95/5 solder.

7.7 FIRE PROTECTION: - Refer to Specification Section – FIRE PROTECTION.

**PART 8 – HVAC PIPING APPLICATIONS**

8.1 GEOTHERMAL/HEAT PUMP LOOP PIPING:

- 8.1.1 Mains and branches – Piping shall be virgin polyethylene with a PE 3408 piping formulation and 345464C or greater cell classification. Pipe shall be SDR 15.5, minimum pressure rating of 110 psi at 73.4°F.
- 8.1.2 Individual Heat Pump Runouts - Type "L" hard copper tubing with wrought copper fittings and 95/5 solder.
- 8.1.3 Special Note: Takeoffs and branch piping to individual coils or heat pumps shall not be connected to the top of hydronic mains. Connection to mains shall be at the side of the main. Also refer to details on the drawings.
- 8.1.4 Transitions from HDPE to Copper – Factory Manufactured Transition required with brass or stainless-steel threads. No metal threads shall be inserted into polyethylene piping, and no polyethylene threads shall be inserted into metal piping.
- 8.1.5 The only acceptable method for joining pipe is by a heat fusion process. Pipe shall be butt or socket fused in accordance with pipe manufacturer's procedures. All piping work shall be performed in accordance with Specification Section – GEOTHERMAL LOOP SYSTEM. Victaulic style 905/908 couplings may be utilized on above ground HKPE applications.
- 8.1.6 Optional 2" and Smaller Individual Heat Pump Runouts - "Pex" Piping: Piping shall be PEX-a (Engel-Method Crosslinked Polyethylene) Piping: ASTM F 876/877 by Uponor. PEX-a Fittings: elbows, adapters, couplings, plugs, tees and multi-port tees (1/2 inch through 3 inch nominal pipe size): ASTM F1960 cold-expansion fitting manufactured from the following material types:
- UNS No. C69300 Lead-free (LF) Brass.
  - 20% glass-filled polysulfone as specified in ASTM D 6394.
  - Unreinforced polysulfone (group 01, class 1, grade 2) as specified in ASTM D 6394.
  - Polyphenylsulfone (group 03, class 1, grade 2) as specified in ASTM D 6394.
  - Blend of polyphenylsulfone (55-80%) and unreinforced polysulfone (rem.) as specified in ASTM D 6394.
  - Reinforcing cold-expansion rings shall be manufactured from the same source as PEX-a piping manufacturer and marked "F1960".

PEX-to-Metal Transition Fittings:

- Manufacturers: Provide fittings from the same manufacturer of the piping.
- Threaded Brass to PEX-a Transition: one-piece brass fitting with male or female threaded adapter and ASTM F 1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring.
- Brass Sweat to PEX-a Transition: one-piece brass fitting with sweat adapter and ASTM F 1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring.
- PEX-a to Flange Transition: two-piece brass fitting with lead-free ProPEX adapter and steel flange conforming to ASME B 16.5.

Store PEX tubing indoors, in cartons or under cover to avoid dirt or foreign material from entering the tubing. Do not expose PEX tubing to direct sunlight for more than six

months. If construction delays are encountered, cover the tubing that is exposed to direct sunlight.

- 8.2 EXTERIOR GEOTHERMAL PIPING: Refer to Specification Section – GEOTHERMAL LOOP SYSTEM.
- 8.3 AIR VENT DISCHARGE LINES: Type "L" soft copper; wrought copper fittings, 95/5 solder. Pipe to a suitable drainage location.
- 8.4 REFRIGERANT PIPING: Type "L" copper tubing with forged or wrought copper fittings and silver soldered joints. Solder must have a minimum of 15% silver content.
- 8.5 CONDENSATE DRAIN LINES: Type "M" copper tubing with sweat fittings and 95/5 solder. Schedule 40 PVC with solvent welded fittings - Do not utilize in return air plenums.
- 8.6 DOMESTIC WATER HEATER COMBUSTION VENT
  - 8.6.1 Schedule 80 CPVC with pressure rated fittings and solvent weld joints. Pipe size, routing, slope, and termination shall be installed per the manufacturer's recommendations. Provide hangers every four feet to properly support the piping.
- 8.7 DOMESTIC WATER HEATER COMBUSTION AIR INTAKE
  - 8.7.1 Schedule 40 PVC with pressure rated fittings and solvent weld joints. Pipe size, routing, slope, and termination shall be installed per the manufacturer's recommendations. Provide hangers every four (4) feet to properly support piping.

**END OF SECTION**

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## **SECTION 20 13 05**

### **GEOHERMAL LOOP SYSTEM**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.

#### **PART 2 – CONTRACTOR QUALIFICATIONS:**

- 2.1 The loop installer/contractor shall have a current International Ground Source Heat Pump Association (IGSHPA) certification, having completed an IGSHPA training course in the fundamentals of design, installation, and operation of ground source systems, and having passed the IGSHPA certification examination.
- 2.2 Ground heat exchanger fabricators shall have completed a heat fusion school in which each participant has performed a heat fusion procedure under direct supervision of a IGSHPA Certified Heat Fusion Technician. The Fusion Technician shall be thoroughly familiar with heat fusion procedures, and have had formal training at a heat fusion school under direct supervision of an IGSHPA certified instructor.
- 2.3 Local and state laws, ordinances, and regulations as they pertain to buried pipe systems shall be strictly followed.

#### **PART 3 – SUBMITTALS:**

- 3.1 Reference Specification Section REQUIRED SHOP DRAWINGS, ETC. for additional requirements.
- 3.2 Submit the following items before construction activities:
- Manufacturer's specification sheets and installation instruction for each component of the system, showing manufacturer, pipe or tube weight, pressure rating, fitting type and joint type for each piping system.
  - Manufacturer's data for geothermal vault and components.
  - Manufacturer's data for the grout mixture. Submit details on grouting procedures, methods and equipment.
  - Written flushing, purging, pressure and flow testing plan. Include purge cart cut sheets.
- 3.3 Submit the following items after construction activities:
- Grout testing results for 10% of vertical bores.
  - Written results of flushing, purging, pressure and flow testing.
  - Schedule dates for warranty period flushing, purging, etc.
  - Survey/Record Drawings with dimensions from fixed benchmarks, depths and sizes.

- Written tracer wire test results.
- Submission of the completed items above is a condition of acceptance and closeout for the Project.

**PART 4 – WARRANTY:**

- 4.1 The entire ground loop system and backfill from a point 5'-0" inside the building shall be warranted for five years from date of substantial completion against any leakage or failure.

**PART 5 – PIPING MATERIALS:**

- 5.1 Acceptable pipe materials for the underground buried portion of the ground heat exchanger are polyethylene as specified in this Section. Piping shall be listed for closed-loop ground source geothermal application. The pipe and fittings of the buried system shall be warranted by the manufacturer for ground source heat pump service.
- 5.2 ACCEPTABLE MANUFACTURERS: Driscoplex 5300 Climate Guard, Centennial Plastics, Charter Plastics, Flying W Plastics, Lamson Vylon Pipe, PolyPipe, Inc.
- 5.3 Manufacturer shall supply a written warranty of 25 years or greater, specifying material replacement and labor allowance.
- 5.4 All pipe and heat fused materials shall be manufactured from a virgin polyethylene extrusion compound material in accordance with ASTM D-2513, Sections 4.1 and 4.2. Pipe shall be manufactured to outside diameters, wall thickness, and respective tolerances as specified in ASTM D-3035 or D-2447. Fittings shall be manufactured to diameters, wall thicknesses, and respective tolerances as specified in ASTM D-2683 for socket fittings and ASTM F-1055 for electrofusion fittings.
- 5.5 The pipe material shall maintain a 1600 psi hydrostatic design basis at 73.4 degrees F per ASTM D-2837, and shall be listed in PPI TR4 as a PE3408 piping formulation. The material shall be high density, polyethylene extrusion compound having a cell classification of PE345434C or PE355434C as specified in ASTM D-3350 except this material shall exhibit zero failures (F0) when tested for 192 or more hours under ASTM D-1693, condition C, as required in ASTM D-3350.
- 5.6 Pipe shall be manufactured in accordance with ASTM D-3035 and sized as follows:
- Pipe sizes 1¼" or less: DR 11 AND rated @ 200 psi.
  - Pipe sizes 1 ½" – 2": DR 15.5
  - Pipe sizes 3" and larger; DR 17
- 5.7 Sufficient information shall be permanently marked on the length of the pipe as defined by the appropriate ASTM pipe standard. Piping shall also have permanent factory length markings.

**PART 6 – PIPE JOINING METHODS:**

- 6.1 The only acceptable method for joining buried pipe systems is by a heat fusion process.

- 6.2 Polyethylene pipe shall be butt or socket fused in accordance with pipe manufacturer's procedures.
- 6.3 "U" bends fittings shall be used at bottom of the vertical bores. "U" bend fitting shall be manufactured by manufacturer of piping materials.

**PART 7 – FLUSHING, PURGING, PRESSURE AND FLOW TESTING:**

- 7.1 Refer to Specification Section PIPE FILLING, CLEANING, FLUSHING, PURGING AND CHEMICAL TREATMENT for additional information and coordination requirements.
- 7.2 Refer to Specification Section TESTING, ADJUSTING AND BALANCING for additional information and coordination requirements.
- 7.3 Include in the bid an additional, complete, piping network purge at substantial completion and at 3, 6, 9 and 12 months from substantial completion.
- 7.4 Successful flushing and purging is critical and shall be accomplished and documented. Notify Engineer prior to flushing and purging. Submit flushing and purging plan to engineer two (2) months prior to commencing this work.
- 7.5 Vertical loops shall be pressure tested before installation, and all horizontal components of the ground heat exchanger will be flushed, pressure and flow tested prior to backfilling. All fusion joints and loop lengths shall be checked to verify that no leaks have occurred due to fusion joining or shipping damage. Heat exchangers shall be tested hydrostatically at 100% of the pipe design rating. No leaks shall occur within a 120 minute period.
- 7.6 The type of purging cart/equipment is critical to successful flushing and purging. The purge cart shall be sterilized before each use. The purge cart shall include a pump that minimally develops 350 gpm of flow at 130 feet of head pressure developed. It shall include a large purge return tank, interconnection piping, inlet/outlet pressure gauges, water flow readout display reversing valve and 4" flexible hose connection. Coordinate so that the vault purge ports match purge cart couplings. The first circuit purged after hose connection shall be purged minimally one hour to remove extra air introduced from the hoses. Once the first circuit is purged, minimally purge other circuits for 30 minutes. Once all well circuits are purged, close all circuit valves and purge piping between vaults and building heat exchanger using building purge ports.
- 7.7 Flow rates shall be compared to calculated values to assure that there is no blockage or kinking of any pipe. Submit written verification of compliance.
- 7.8 A minimum velocity of 3 ft/sec in each piping section must be maintained until all air is removed. The system shall also be forward and reversed to remove all debris. Purging of one wellfield row shall be witnessed by the Engineer, Owner, Mechanical Contractor, General Contractor and the Test and Balance Contractor. The Test and Balance Contractor shall confirm the minimum velocities are obtained during the purging process and shall also measure supply and return pressures. The Contractor shall provide P/T plugs as required by the Test and Balance Contractor. The Contractor shall provide all

means and methods necessary to insure minimum velocities are obtained. After one test is confirmed, the other wellfield rows shall be tested utilizing the same procedure. The Test and Balance Contractor shall confirm all minimum circuit, flow rates are obtained for all wellfield piping.

- 7.9 Final purging of air from the entire building loop and wellfield loop shall be performed by the wellfield purging contractor so that air in the building will not be transferred with the wellfield. Coordinate with the Mechanical Contractor.

#### **PART 8 – HORIZONTAL PIPING SYSTEMS:**

- 8.1 Refer to Section EXCAVATION, BACKFILLING AND TRENCHING AND GRADING for additional requirements.
- 8.2 Sharp bending of pipe around trench corners shall be prevented by using a shovel to round corners, or by installing an appropriate elbow fitting. Manufacturer's procedures shall be followed.
- 8.3 Backfilling procedure will include prevention of any sharp-edged rocks from coming into contact with the pipe by removal of the rocks before backfilling, backfill with #8 rock. Provide a minimum of 6" cover over pipe with back filled material. Clods resulting from use of a backhoe shall be broken so as not to form air pockets around the pipe which will reduce heat conduction between the earth and the pipe. The flow of backfill soil must be controlled to prevent bridging and the formation of air pockets. Several slow passes with an angled backfill blade are required. Flooding is required to assure removal of air pockets. Minimum bury depth of piping shall be 36" to top of pipe.
- 8.4 Horizontal return bends must be backfilled by hand to properly support the pipes and prevent kinking.
- 8.5 Install continuous tracer wires on each wellfield circuit in and out of the geothermal vault and the building. Provide an additional 36" of coiled tracer wire on each end and attach in vault at each circuit. Provide an additional 36' of coiled tracer wire on each end and attach in building at each circuit riser. Perform tracer wire testing for all tracer wires in conjunction with the Owner/Engineer – this is a condition of acceptance and closeout.
- 8.6 Install continuous tracer wires on each wellfield circuit in and out of the building. Provide an additional 36" of coiled tracer wire on each end and attach in building at each circuit riser. Perform tracer wire testing for all tracer wires in conjunction with the Owner/Engineer – this is a condition of acceptance and closeout.

#### **PART 9 – BORE HOLE AND GROUTING:**

- 9.1 The Contractor shall accept the site as-is and is responsible for any and all required steel casings. If an area of voids is encountered, the Contractor shall either fill or re-drill wells in an approved area and extend piping to them. No night drilling will be allowed.
- 9.2 The Contractor shall bore wells of a sufficient diameter to allow installation of the piping and U-bend and a 1-1/4" (minimum) HDPE tremie pipe for grout installation, but shall be no less than 6"- 6 1/2".

- 9.3 Bore holes shall be grouted to ensure good heat transfer. Local and state laws and regulations for grouting and backfilling shall be followed. See IGSHPA Grouting Procedures Manual for detailed grouting procedures.
- 9.4 Vertical bores shall be drilled to sufficient depths to ensure that the entire length of U-tube is inserted. This may require the bore to be drilled several feet deeper than the U-tube length.
- 9.5 All U-tube joints shall be visually inspected for integrity as specified by the pipe manufacturer (alignment of joints, proper bead roll-back) before insertion into the bore hole.
- 9.6 The bore hole annulus shall be completely grouted to ensure there are no air voids and to ensure there is consistent contact between the vertical piping and the bore hole formation. This will require the bore annulus to be filled with grout from the bottom to the top with a "tremie" tube.
- 9.7 The entire bore shall be grouted with a thermally enhanced grout mixture with a thermal conductivity of 1.00 Btu/hr-ft-°F. Grout shall be GeoPro Thermal Grout Lite 100 bentonite mixture or approved equal. Mixture shall be field mixed in strict accordance with manufacturer's recommendations. Grout mixture shall be mechanically pumped with a positive displacement pump into bore hole from bottom to top utilizing a tremie tube.
- 9.8 Through the course of the project, sample grout specimens shall be randomly (chosen by Construction Manager) taken of the mixed grouting material by this Contractor for 10% of the vertical bores. An analysis shall be performed by the grout manufacturer to verify proper thermal performance and grout mixture. This Contractor shall submit these reports to the Owner, Architect and Engineer to verify compliance with the installation specifications.

**PART 10 – ADDITIONAL INSTALLATION REQUIREMENTS:**

- 10.1 Underground land survey of the entire geothermal wellfield system per GENERAL PROVISIONS - MECHANICAL. This shall include all horizontal piping, vaults, vertical bore locations and dimension from above grade fixed benchmarks. The underground survey shall be included in the closeout documentation.
- 10.2 DUST CONTROL: The Contractor shall be responsible for and shall provide dust control. Dust shall not be allowed to leave the construction site boundaries, and furthermore, shall not be allowed to enter the building or accumulate on the building exterior. When needed to meet these requirements, the Contractor shall provide and operate a mechanical dust collection system to control dust at the source. Mechanical dust collection system shall consist of collection hood at the source ducted to a dust collector which separates dust from the airstream. Dust shall be collected into sealed containers for disposal by the Contractor. Water spraying may be used but shall not be considered a substitute for mechanical dust collection at the source when required.

- 10.3 SURFACE WATER / MUD / SLURRY CONTROL: The Contractor shall be responsible for and shall provide control of all ground flowing fluids resulting from drilling operations. The Contractor shall erect silt fences or other structures as required to contain drill cuttings, mud, slurry, etc. within the construction site boundaries. In the event this requirement is not met, the Contractor shall provide all remediation measures as required by all authorities having jurisdiction over such events.

**END OF SECTION**

## **SECTION 20 13 10**

### **PIPE FILLING, CLEANING, FLUSHING, PURGING AND CHEMICAL TREATMENT**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 Review the Specification Section – REQUIRED SHOP DRAWINGS, ETC., and provide all documentations called for therein.
- 1.3 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected and approved systems. Claims for additional cost or change orders will immediately be rejected.
- 1.4 Maintain a water treatment program for the closed loop piping systems. It is the Contractor's responsibility to contact the engineer 2 weeks in advance to any treatments performed on the systems. It is the Engineer's discretion whether or not this process should be monitored after notification.
- 1.5 A pre-installation meeting shall be held with the Owner, Architect, Engineer, General Contractor, Mechanical Contractor, Pipe Fitter Foreman, Geothermal Contractor and Chemical Treatment Contractor to discuss goals and expectations for cleaning, flushing, purging and chemical treatment.
- 1.6 Chemicals, equipment, testing services, and chemical application shall be supplied by a single water treatment company for undivided responsibility. The water treatment company shall be a recognized specialist, active in the field of commercial/industrial water treatment for at least 5 years. The water treatment company shall have regional water analysis laboratories, service department, and full-time representatives located within the area of the job site or facility.
- 1.7 Prior to any construction, the Contractor shall sample the existing closed loop chemicals and provide chemical treatment water quality analysis. Provide levels for all items noted in paragraph "Water Quality Minimum Performance Requirements for Closed Loops". Provide a report to the Engineer.
- 1.8 Be advised the existing loop contains an anti-freeze mixture. Prior to any construction, the Contractor shall sample the existing closed loop and provide anti-freeze mixture data.

- 1.9 Furnish initial supply of the closed loop chemicals for each system. This contractor shall retest the systems after 3, 6, 9 and 12 months upon substantial completion to verify the proper dosage is in each system. Provide all closed loop chemicals and anti-freeze for the first year. The Contractor shall determine the appropriate chemical volumes for each system. Each system's water shall be tested for proper chemical parameters, clarity, and biological activity. If needed, provide chemical addition, including anti-freeze. Provide any laboratory and technical assistance required to achieve a successful program.
- 1.10 As a condition of acceptance and project closeout, a summary of water quality and treatment shall be provided in writing to the Owner and/or Engineer after the water treatment services have been successfully completed. The closeout documentation shall include dates for warranty testing.
- 1.11 Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- 1.12 WATER QUALITY MINIMUM PERFORMANCE REQUIREMENTS FOR CLOSED LOOPS:
- Closed hydronic systems shall maintain a pH value within 9 – 10.5 pH for iron and copper piping loops.
  - Total Anaerobic Plate Count - Maintain a maximum value of 100 organisms/ml.
  - Nitrate Reducers (Denitrifying Bacteria) - Maintain below a maximum value of 10,000 organisms/ml.
  - Sulfate Reducers - Maintain below a maximum value of 200 organisms/ml.
  - Iron Bacteria - Maintain below a maximum value of 100 organisms/ml.
  - Slime Bacteria - Maintain below a maximum value of 1,000 organisms/ml.

**PART 2 – CLEANING AND FLUSHING OF HYDRONIC PIPING:**

- 2.1 This project consists of the following Hydronic Piping Loops:
- Geothermal Heat Pump Water
- 2.2 There are several precautions which must be observed during piping installation. This contractor is advised to read all of the manufacturer's instructions prior to commencing the installation. This cleaning and flushing of the systems must be accomplished. Refer to Specification Section GEOTHERMAL LOOP SYSTEM for geothermal system requirements.
- 2.3 All water circulating systems for the project shall be thoroughly cleaned before placing in operation to rid the system of dirt, piping compound, mill scale, oil and any and all other material foreign to the water. During construction, extreme care shall be exercised to prevent all dirt and other foreign matter from entering the pipe or other parts of the system. Pipe stored on the project shall have the open ends capped and equipment

shall have all openings fully protected. Before erection, each piece of pipe, fitting or valve shall be visually examined and all dirt removed.

2.4 After the piping is complete:

2.4.1 The Contractor shall first fill the piping loops and all runouts with clear water. The loop water shall be circulated for one hour with make-up water open and boiler drain open to accomplish initial flushing of the system.

2.4.2 After initial flushing, all strainers shall be cleaned and the individual terminal devices and coils shall be connected permanently to the supply and return runouts conditions and then add trisodium phosphate in an aqueous solution to the system at the proportion of one pound per fifty gallons of water in the system.

2.4.3 After the system is filled with this solution, the loop shall be allowed to circulate for 24 hours.

2.4.4 The Chemical Treatment Contractor shall be given notice by the Contractor of scheduling this cleaning and, if the Engineer's representative deems it necessary, the operation shall be repeated.

2.4.5 After the system has been completely cleaned as specified herein, it shall be tested by litmus paper or other dependable method and shall be left on the slightly alkaline side.

2.4.6 If the system is found to be still on the acid side, the cleaning by use of Trisodium Phosphate shall be repeated.

2.4.7 After the cleaning including all strainers and flushing is complete, and approved by CMTA, the Contractor shall provide the proper water treatment for the system.

2.5 After the heat pump loop is complete:

2.5.1 The Contractor shall first close the WSHP isolation valves and open the WSHP bypass valves.

2.5.2 Fill the piping loops and all runouts with clear water. The loop water shall be circulated for one hour with make-up water open and boiler drain open to accomplish initial flushing of the system.

2.5.3 After initial flushing, all strainers shall be cleaned and the Contractor shall open the WSHP isolation valves and close the WSHP bypass valves and then add trisodium phosphate in an aqueous solution to the system at the proportion of one pound per fifty gallons of water in the system.

2.5.4 After the system is filled with this solution, the loop shall be allowed to circulate for 24 hours.

2.5.5 The Chemical Treatment Contractor shall be given notice by the Contractor of scheduling this cleaning and, if the Engineer's representative deems it necessary, the operation shall be repeated.

- 2.5.6 After the system has been completely cleaned as specified herein, it shall be tested by litmus paper or other dependable method and shall be left on the slightly alkaline side.
- 2.5.7 If the system is found to be still on the acid side, the cleaning by use of Trisodium Phosphate shall be repeated.
- 2.5.8 After the cleaning, including all strainers and flushing is complete, and approved by CMTA, the Contractor shall provide the proper water treatment for the system.

**PART 3 – CLOSED LOOP CHEMICAL TREATMENT:**

- 3.1 Provide a 5-gallon pot feeder valved and capped port for injection of the closed loop chemicals into the system.
- 3.2 After the system is complete it shall be thoroughly cleaned before placing in operation to rid the system of dirt, biological contamination, piping compound, loose mill scale, oil, and any and all other material foreign to the water as previously specified.
- 3.3 Before chemical cleaning and sterilization of the entire system, the field and hydronic loop and mains shall be individually flushed and purged until free of dirt, debris, and air. During the flushing/purging and chemical cleaning processes the supply and return run-outs shall be temporarily placed in bypass operation. See SYSTEM FILLING & PURGING PLAN for additional information.
- 3.4 After chemical cleaning, the entire system shall be sterilized with a biocide added at recommended dosage to effectively kill any present microorganisms. Add glutaraldehyde to achieve 60 – 200 ppm of active ingredient or isothiazoline to achieve 10 – 13 ppm active. Do not flush biocide from system. Corrosion inhibitors shall be installed in closed loop systems containing metal piping, fittings, accessories, etc.
- 3.5 A bacteria analysis shall be performed to ascertain biological cleanliness of system. If bacteria counts are above set parameters then sterilization process shall be repeated until bacteria counts are at or below acceptable levels. Microbiological limits are listed under “Water Quality Minimum Performance Requirements” elsewhere in this Specification Section.
- 3.6 Within 48 hours of the completion of the sterilization and confirmation that bio-levels are within the specified parameters, implement a water treatment program to passivate all metal surfaces.

**END OF SECTION**

## **SECTION 20 21 00**

### **VALVES**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 Each Contractor shall provide all valves required to control, maintain and direct flow of all fluid systems indicated or specified. This shall include, but may not be limited to all valves of all types including balancing valves, air vents, drain valves, check valves, special valves for special systems, etc., for all Mechanical Systems.
- 1.3 ACCEPTABLE MANUFACTURERS: Lunkheimer, Powell, Nibco, Crane, Jenkins, T & S Brass, Walworth, Milwaukee, DeZurik, Consolidated Valve Industries, Inc., Bell & Gossett, Apollo.
- 1.4 The following type valves shall not be acceptable: Zinc, plastic, fiber or non-metallic.
- 1.5 Each type of valve shall be of one manufacturer, i.e., ball valves, one manufacturer, butterfly valves, one manufacturer, check valves, one manufacturer, etc.
- 1.6 All valves shall comply with current Federal, State and Local Codes. All valves shall be new and of first quality. All valves shall be designed and rated for the service to which they are applied. Zinc, plastic, fiber or non-metallic valves shall not be acceptable.
- 1.7 Contractor shall provide colored tape on ceiling tile where valves are located above ceiling. Provide access panels where valves are located above hard ceiling.

#### **PART 2 – DOMESTIC WATER APPLICATIONS:**

- 2.1 GATE VALVE (3" AND UNDER): Use ball valves as specified.
- 2.2 GATE VALVE (4" AND LARGER): Gate valve shall have bronze body, bonnet and solid wedge. Gate valve shall be rising stem with bolted bonnet and solid wedge. Valve shall have rated for 150 psi working pressure. Gate valve shall be Nibco T-134 for threaded ends or Nibco S-134 for solder ends.
- 2.3 GLOBE VALVES (2" AND UNDER): Globe Valves shall have bronze body, bonnet and disc holder. Globe valve shall have union bonnet, integral seat, teflon or stainless-steel renewable disc and be rated for 150 psi working pressure. Globe valve shall be Nibco T-235 for threaded ends or Nibco S-235 for solder ends.
- 2.4 CHECK VALVE (2" AND UNDER): Check valve shall have bronze body, disc and hinge. check valve shall be Y-pattern type, horizontal swing, renewable disc and rated for 150

psi working pressure. Check valve shall be Nibco T-413 for threaded ends or Nibco S-413 for solder ends.

- 2.5 TWO PIECE BALL VALVE (2" AND UNDER): Ball valve shall have bronze body, ball and reinforced, water tight seat. Valve shall be two-piece construction. Valve shall be "full-port" type. Valve handle shall only require quarter turn to go from full open to full close. The handle shall be removable with vinyl grip. Valve shall be rated for 180 degrees F water temperature and 150 psi working pressure. Ball valve shall be Nibco T-585 for threaded ends and Nibco S-585 for solder ends.
- 2.6 BALL VALVES (2½"-3"): Ball valve shall have bronze body, ball and reinforced, watertight seat. Valve handle shall only require quarter turn to go from full open to full close. The handle shall be removable with vinyl grip. Valve shall be rated for 250 degrees F water temperature and 200 psi working pressure. Ball valve shall be Nibco T-580 for threaded ends and Nibco S-580 for solder ends. Provide extended handles for all ball valves installed in an insulated system.
- 2.7 THREE PIECE BALL VALVE (2" AND UNDER): Ball valve shall have bronze body, ball and reinforced, water tight seat. Valve shall be three-piece, swing-out, construction to facilitate inspection and repair. Valve shall be "full-port" type. Valve handle shall only require quarter turn to go from full open to full close. The handle shall be removable with vinyl grip. Valve shall be rated for 180 degrees F water temperature and 150 psi working pressure. Ball valve shall be Nibco T-595 for threaded ends and Nibco S-595 for solder ends.
- 2.8 STRAINERS (2" AND UNDER): Watts 77S Series "Y" type strainer with cast iron body and threaded ends. Screen shall be 20 mesh stainless steel. Strainer shall be provided with cleanout plug and be rated for 200 psi working pressure.
- 2.9 STRAINERS (2½" AND LARGER): Watts 77F Series "Y" type strainer with semi-steel body and flanged ends. Screen shall be 20 mesh stainless steel. Strainer shall be provided with bolted cleanout and be rated for 200 psi working pressure.
- 2.10 PRESSURE REDUCING VALVES: Watts #U5B water pressure reading valve with bronze body, bolted bonnet, integral stainless-steel strainer and outlet water pressure gauge. Internal disc, diaphragm and stainless-steel seat shall all be removable. Valve shall be rated for inlet water pressures up to 300 psi. Water pressure reducing valves shall be provided for all equipment where water pressure exceeds the equipment manufacturer's ratings.
- 2.11 VACUUM BREAKERS: Watts #288A atmospheric type vacuum breaker with brass body. Vacuum breaker shall be rated for 210 degrees F and 125 psi working pressure and shall meet ASSE Standard 1001.
- 2.12 DOUBLE CHECK VALVE: Double check valve shall have bronze body construction and be provided with inlet strainer, two (2) gate valves for isolation and three (3) test ports. Assembly shall be rated for 110 degrees F water temperature and 175 psi water pressure. Assembly must meet requirements of AWWA Standard C506. For sizes 2" and less, provide Watts #900 (or equal) with threaded ends. For sizes 2½" and larger, provide Watts #709 (or equal) with flange ends.

- 2.13 REDUCED PRESSURE BACKFLOW PREVENTERS: Reduced pressure backflow preventers shall be provided with inlet strainer, two (2) gate valves for isolation, three (3) test ports and air gap fitting. Assembly shall be rated for 110 degrees F water temperature and 175 psi water pressure. RPBP shall be UL listed and meet AWWA C511 standards. Watts #909 or equal by Wilkins or Conbraco. All valves 3" and less in size shall bronze body construction, over 3" in size shall have epoxy coated cast iron bodies. Assemblies 2" and under in size shall have threaded ends, over 2" in size shall have flange ends. Perform backflow preventer test and provide results with closeout documentation.
- 2.14 BALANCING VALVE: Bell & Gossett "Circuit Setter" Model CB or equal balancing valve. All valves to be of bronze body/brass ball construction with glass and carbon filled TFE seat rings. Valves to have differential pressure read-out ports across valve seat area. Read-out ports to be fitted with internal EPT inserts and check valves. Valve bodies to have 1/4" NPT tapped drain/purge port. Valves to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position. All valves to have calibrated nameplates to assure specific valve settings. Valves shall be designed for positive shut-off.

**PART 3 – HVAC APPLICATIONS:**

- 3.1 GATE VALVE (3" AND UNDER): Use ball valves as specified.
- 3.2 GLOBE VALVE (2" AND UNDER): Globe valve shall have bronze body, bonnet and disc holder. Globe valve shall have union bonnet, integral seat, teflon or stainless-steel renewable disc and be rated for 200 psi working pressure. Globe valve shall be Nibco T-235 for threaded ends or Nibco S-235 for solder ends.
- 3.3 GLOBE VALVES (2½" AND OVER): Globe valve shall have cast iron body, bolted bonnet, bronze disc, renewable seat and have outside screw and yoke. Handwheel to be cast iron. Globe valve to be rated for 200 psi working pressure. Globe valve shall be Nibco F-718 for flanged ends or Nibco T-718 for threaded ends. Threaded ends valve allowed for sizes 3" and less only.
- 3.4 CHECK VALVES (2" AND LESS): Check valve shall have bronze body, disc and hinge. Check valve shall be Y-pattern type horizontal swing, renewable disc and rated for 200 psi working pressure. Check valve shall be Nibco T-413 for threaded ends or Nibco S-413 for solder ends.
- 3.5 CHECK VALVES (2½" AND LARGER): Check valve shall have cast iron body and cast-iron bolted bonnet the disc and seat ring shall be bronze. Check valve shall be horizontal swing with renewable seat and disc. Valve shall be rated for 200 psi working pressure. Check valve shall be Nibco F-918 for flanged ends and Nibco T-918 for threaded ends. Threaded ends valve allowed for sizes 3" and less only.
- 3.6 TWO PIECE BALL VALVES (2" AND UNDER): Ball valve shall have bronze body, ball and reinforced, watertight seat. Valve shall be two-piece construction. Valve shall be "full port" type. Valve handle shall only require quarter turn to go from full open to full close. The handle shall be removable with vinyl grip. Valve shall be rated for 250

degrees F water temperature and 200 psi working pressure. Ball valve shall be Nibco T-585 for threaded ends and Nibco S-585 for solder ends. Provide extended handles for all ball valves installed in insulated piping systems.

- 3.7 BALL VALVES (2½"-3"): Ball valve shall have bronze body, ball and reinforced, watertight seat. Valve handle shall only require quarter turn to go from full open to full close. The handle shall be removable with vinyl grip. Valve shall be rated for 250 degrees F water temperature and 200 psi working pressure. Ball valve shall be Nibco T-580 for threaded ends and Nibco S-580 for solder ends. Provide extended handles for all ball valves installed in chilled water piping systems.
- 3.8 BUTTERFLY VALVE (4" AND LARGER): Butterfly valve shall have cast iron body with bronze disc. Valve to have extended neck to allow for insulation and be "lug" type configuration. Interior liner shall be made of EPDM. Lever handle shall be lock type with 10 position settings. Valve to be rated for 200 psi working and have positive shut-off equal to Hammond 6411 Series. Provide a gear operator for all valves 8" and larger.
- 3.9 STRAINERS (2" AND UNDER): Watts 77S Series "Y" type strainer with cast iron body and threaded ends. Screen shall be 20 mesh stainless steel. Strainer shall be provided with cleanout plug and be rated for 200 psi working pressure.
- 3.10 STRAINERS (2½" AND LARGER): Watts 77F Series "Y" type strainer with semi-steel body and flanged ends. Screen shall be 20 mesh stainless steel. Strainer shall be provided with bolted cleanout and be rated for 200 psi working pressure.
- 3.11 BALANCING VALVE (4" AND LESS): Balancing valve shall have bronze or cast-iron body. Valves to have differential pressure readout ports across valve seat area with integral check valves. Valve shall be equipped with memory stop. Valves to have threaded ends for sizes 3" and less, flanged ends for larger sizes. Valve to be provided with performed molded insulation casing. Design working pressure and temperature to be 200 psi at 250 degrees F balancing valve shall be similar to Bell & Gossett Model CB. Provide with balancing valves, one (1) water gpm readout kit to be turned over to Owner which shall include a differential pressure meter with full scale overrange protection, hoses, readout probes, filters, carry and calculator.
- 3.12 FLEXIBLE CONNECTION: Pumpsaver SMP or equal braided stainless-steel pump connector(s). Construction to be of annular corrugated stainless steel close-pitch hose with stainless steel overbraid. The corrugated metal hose, braid(s), and a stainless-steel ring-ferrule/band (material gauge not less than .048") must be integrally seal-welded using a 100% circumferential, full-penetration TIG weld. End fittings shall be flat-face plate steel flanges with 150# ANSI drilling and outside diameter. Fittings must be attached using a 100% circumferential TIG weld. Braided stainless steel pump connector(s) must be suitable for operating temperatures up to 850 degrees F. The rated working pressure of the braided metal hose must have a minimum 4:1 safety factor. Each braided stainless-steel pump connector shall be individually leak tested by the manufacturer using air-under-water or hydrostatic pressure. Flanged pump connectors shall be prepared for shipment using cut-to-length spacers, securely positioned between the flanges to prevent axial compression damage and maintain the manufactured length. Spacers must be removed prior to system start up.

- 3.13 AUTOMATIC AIR VENT: Bell & Gossett Model 107A high capacity float actuated automatic air vent with cast iron body and bonnet. Vent to be rated for 150 psi working pressure and 240 degrees F working temperature. Pipe discharge to nearest floor drain unless noted otherwise.
- 3.14 MANUAL AIR VENT: Bell & Gossett Model 78 manual air vent with cast brass body and built-in check valve. Vent to be rated for 150 psi working pressure and 240 degrees F working temperature. Install with 12" length of 1/4" soft copper discharge piping unless noted otherwise.

**PART 4 – NATURAL GAS APPLICATIONS:**

- 4.1 GAS BALL VALVE (2" AND LESS): Nibco TFP600N gas ball valve. Valve shall forge two-piece brass, CSA/CGA CR 91-002 certified, 5 psig rating, lever handle, full port ball valve, lubricated shaft, PTFE seats, blowout proof stem and threaded ends.
- 4.2 GAS LUBRICATED PLUG VALVE, (2½" AND GREATER): Homestead lubricated industrial plug valve, Model 611/612, 100% round port, leak-proof, spring loaded ball and lubricant sealed check valve. Provide with threaded ends and lever handle.

**END OF SECTION**

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## **SECTION 20 22 00**

### **INSULATION - MECHANICAL**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 Work under this section shall include all labor, equipment, accessories, materials and services required to furnish and install all insulation, fittings and finishes for all mechanical systems specified herein and/or as indicated.
- 1.3 Application of insulation materials shall be performed in accordance with manufacturer's written recommendations. Where thickness of insulation is not specified, use applicable thickness recommended by manufacturer for specific use.
- 1.4 Insulation thicknesses shall comply with the latest version of ASHRAE 90.1 and IECC at a minimum.
- 1.5 All insulation materials shall be installed per the latest edition of the National Commercial and Industrial Insulation Standards.
- 1.6 Insulation shall be installed by a company regularly engaged in the application of insulation and any work deemed unacceptable by the Engineer shall be removed and properly installed at the expense of the Contractor.
- 1.7 The Contractor shall photograph any installations prior to concealment. This includes duct risers in chases and at rooftop equipment.

#### **PART 2 – ACCEPTABLE MANUFACTURERS:**

- 2.1 Johns Manville, Knauf, Owens-Corning.

#### **PART 3 – FIRE RATINGS AND STANDARDS:**

- 3.1 Insulations, jackets, facings, adhesives, mastics, tapes, fitting materials, etc. shall have composite fire and smoke hazard ratings as tested by ASTM E-84, NFPA 255 and UL 723 procedures not exceeding Flame Spread 25, Smoke Developed 50 and Fuel Contributed 50.
- 3.2 All products and their packaging shall bear a label indicating above requirements are not exceeded.
- 3.3 Fiber glass duct wrap shall meet the requirements of Scientific Certification Systems Certification or Greenguard Validation of Formaldehyde Free.

- 3.4 Fiber glass mechanical board shall meet the requirement of the Greenguard Standards for Low-Emitting Products.
- 3.5 Fiber glass pipe insulation shall meet the requirement of the Greenguard Gold level standard.

**PART 4 – GENERAL APPLICATION REQUIREMENTS:**

- 4.1 "Concealed", where used herein, shall mean hidden from sight as in trenches, chases, furred spaces, pipe shafts, or above hung finished ceilings. "Exposed" shall mean that piping or equipment is not "concealed" as defined above. Piping and equipment in service tunnels, mechanical equipment rooms, storage areas, or unfinished rooms is to be considered "exposed".
- 4.2 Insulation shall be applied on clean, dry surfaces in a neat and workmanlike manner reflecting the best current practices in the trade. Insulation shall not be applied to piping, ductwork or equipment until tested, inspected and released for insulation.
- 4.3 Where more than one thickness of insulation is required, joints (both longitudinal and transverse) shall be staggered.
- 4.4 All insulation shall be continuous through walls, ceiling openings and sleeves. However, insulation shall be broken through fire walls. All covered pipe and ductwork is to be located a sufficient distance from walls, other pipe, ductwork and other obstacles to permit the application of the full thickness of insulation specified. If necessary, extra fittings and pipe are to be used. No noticeable deformation of insulation or discontinuity of vapor seal, where required, will be accepted. Coordinate work with plumbers, pipe fitters, etc. to assure hanger locations agree with location of insulation inserts.
- 4.5 Existing and/or new insulation removed and/or damaged during course of construction shall be repaired or replaced by the Contractor at their expense.
- 4.6 Vapor barrier jackets shall be applied with a continuous unbroken vapor seal. Do not use staples through the jacket. NO EXCEPTIONS!
- 4.7 All insulation shall be installed with joints butted firmly together.
- 4.8 The Contractor shall insure that all insulation (piping, ductwork, equipment, etc.) is completely continuous along all conduits, equipment, connection routes, etc. carrying cold fluids (air, water, other) and that condensation can, in no way, collect in or on the insulation, equipment, conduits, etc. Any such occurrence of condensation collection and/or damage therefrom shall be repaired solely at the expense of the Contractor.
- 4.9 Unless otherwise specified or allowed, closed cell type insulation shall not be acceptable.

**PART 5 – PIPING SYSTEMS:**

- 5.1 Seal insulation and jacket at all points where insulation terminates at unions, flanges, valves and equipment. This applies to hot water lines only as cold-water lines require continuous insulation and vapor barrier.
- 5.2 Pipe insulation shall extend around valve bodies to above drain pans in hydronic equipment over pumps, etc. to insure no condensation drip or collection.
- 5.3 Valves, flanges and unions shall only be insulated when installed on cold fluid piping whose surface temperature will be at or below the dew point temperature of the ambient air.
- 5.4 Insulation shall not extend through fire and smoke walls. Pack sleeve at fire and smoke wall with approved fire retardant packing similar to mineral wool and seal with approved sealant.
- 5.5 Metal insulation shields and inserts are required at all pipe hangers where the piping is insulated. Metal shields shall be constructed of galvanized steel, formed to a 180-degree arc. Insulation shields shall be the following size:
- | Pipe Size   | Shield Gauge | Shield Length |
|-------------|--------------|---------------|
| 2" and less | 20           | 12"           |
| 2 ½"- 4"    | 18           | 12"           |
| 5"- 10"     | 16           | 18"           |
| Over 10"    | 14           | 24"           |
- 5.6 Insulated pipes 2" in diameter and larger shall be additionally supported with wood inserts of sufficient compressive strength to carry the weight of the pipe and fluid. Inserts shall extend beyond extend beyond the hanger and shall be at least 6" in length.
- 5.7 Provide premolded PVC insulated fitting covers on all pipe fittings, flanges, valves and pipe terminations. Fittings shall be insulated by applying the proper factory precut insulation insert to the pipe fitting. The ends of the insulation insert shall be tucked snugly into the throat of the fitting and the edges adjacent to the pipe insulation tufted and tucked in, fully insulating the pipe fitting. The proper thickness of insulation must be applied to keep the jacket temperature less than 150°F. An approved vapor retarder mastic compatible with the PVC shall be applied around the edges of the adjoining pipe insulation and on the fitting cover throat overlap seam. The PVC fitting cover shall then be applied and secured with pressure sensitive tape along the circumferential edges. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2" on the downward side. On fittings where the operating temperature is below 50°F, two or more layers of the insulation inserts shall be applied with the first layer being secured with a few wrappings of fiber glass yarn to eliminate voids. One additional insert shall be used for each additional 1" of pipe insulation above 1-1/2". All joints shall be fully sealed.
- 5.8 PIPE INSULATION MATERIAL: Insulation shall be Knauf "Earthwool 1000° Pipe Insulation ASJ+/SSL+" or approved equivalent fiberglass pipe insulation with an all

service jacket. The insulation shall be a heavy density, pipe insulation with a K factor not exceeding 0.27 Btu per inch/h.ft<sup>2</sup> °F at 75°F mean temperature. The insulation shall be wrapped with a vapor barrier jacket. The jacket shall have an inside foil surface with self sealing lap and a water vapor permeability of 0.02 perm/inch. All circumferential joints shall be vapor sealed with butt strips. All insulation shall be installed in strict accordance with the manufacturer's recommendations. The following pipes shall be insulated with the minimum thickness of insulation as noted.

- 5.8.1 Domestic Cold Water: 1" thick insulation (delete if PEX piping is used)
- 5.8.2 HVAC Fill Lines: 1" thick insulation (delete if PEX piping is used)
- 5.8.3 Domestic Hot Water & Return Lines:
  - Piping 1-1/4" and less: 1" thick insulation (1/2" thick if PEX piping is used)
  - Piping 1-1/2" and greater: 1-1/2" thick insulation (1/2" thick if PEX piping is used)
- 5.8.4 Refrigerant Suction Lines:
  - Piping 1-1/4" and less: 1/2" thick elastomeric insulation
  - All exterior piping: 1" thick elastomeric insulation with Ideal 777 jacketing
- 5.8.5 Geothermal Heat Pump Piping: 1" thick (Not required for HDPE or Pex piping exposed in mechanical rooms or closets over concrete floor). Any piping above or over a ceiling or concealed shall be insulated.
- 5.8.6 Condensate Drain Lines: 1/2" thick (Not required for PVC piping exposed in mechanical rooms or closets over concrete floor). Any piping above or over a ceiling or concealed shall be insulated.
- 5.8.7 Floor Drain Sanitary Pipes: All floor drains that have condensate spilled to the drain, and the sanitary pipe is not below slab, shall have its respective sanitary pipe insulated with 1" thickness. Insulate the pipe until it connects to a 4" main, but a minimum of 20 feet in the direction of flow.
- 5.9 EXPOSED, INTERIOR (INTERIOR FINISHED ROOMS, STORAGE ROOMS, ETC.) PIPING JACKETS: All insulated piping installed in the above areas shall have a 6 oz. canvas jacket with fire retardant lagging apply to the insulation specified for the piping.
- 5.10 EXPOSED, EXTERIOR PIPING JACKETS: In addition to the insulation specified for the exterior pipe, provide 3M venture clad 1577CW. The jackets shall be installed as recommended by the manufacturer to maintain water tight seal on all exposed piping including elbows. All longitudinal and transverse seams to be sealed water tight.

#### **PART 6 – DUCTWORK SYSTEMS:**

- 6.1 Duct sizes indicated are the net free area inside clear dimensions; where ducts are internally lined, overall dimensions shall be increased accordingly.

- 6.2 Duct insulation shall extend completely to all registers, grilles, diffusers, and louver outlets, etc., to insure no condensation drip or collection.
- 6.3 EXTERNAL INSULATION FOR SUPPLY AIR DUCTWORK: Knauf "Friendly Feel" faced, Duct Wrap, 0.75 PCF density, 2.2" thick or approved equivalent. Wrap shall be factory laminated to a reinforced foil kraft vapor barrier facing (FRK) with a 2" stapling flange at one edge. The installed R value shall be a minimum of 6.0. Flame spread 25, smoke developed 50, vapor barrier performance 0.02 perms per inch.
- Pre-conditioned outside air supply ductwork downstream of OA unit (under positive pressure) and exhaust air ductwork upstream of OA unit (under negative pressure) does not require insulation. All other duct including louver plenums requires installation per the above.
- 6.4 DUCT SOUND ABSORBER / DUCTWRAP: In addition to the duct insulation specified, install 1" thick Kinetics KBC-100RBQ (or Sound Seal BBC-1 B-10FS QFA-1) limp barrier material (1.3 lb/sq ft), reinforced with a fiber glass screen, loaded with barium sulphate, with a quilt faced fiber glass absorber on one side. Install per manufacturer's instructions. Minimum sound transmission loss per octave band shall be 125Hz-10dB/250Hz-16dB/500 Hz-22dB/1000Hz-30dB/2000Hz-39dB/4000Hz-43dB/STC-27. Provide steel banding to ensure restraint of duct wrap. Only use where noted on the drawings.
- 6.5 EXTERNALLY INSULATED DUCT – OUTDOORS: 2" rigid fiberglass industrial board with foil scrim kraft vapor barrier facing, 6.0 PCF density,  $K=0.23 \text{ Btu in/hr.ft}^2 \text{ }^\circ\text{F @ } 75^\circ\text{F}$ . Owens/Corning or approved equivalent industrial installation type 705. Weather proofing shall be Polyguard Alumaguard, all weather, proofing jacket with brite white finish, or approved equivalent. Use semi-rigid Type 703/704 insulation for round ducts. The installed R-value shall be a minimum of 8.0.

**END OF SECTION**

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## **SECTION 20 23 00**

### **THERMOMETERS, PRESSURE GAUGES AND OTHER MONITORING INSTRUMENTS**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall include all thermometers, pressure gauges and/or compound gauges at the locations indicated. All pressure gauges and/or compound gauges shall be provided with 1/4 turn ball valves to allow the gauge to be removed and replaced without shutting down system.

#### **PART 2 – THERMOMETERS AND PRESSURE GAUGES:**

- 2.1 Gauges and thermometers shall be Miljoco, Marsh, Terice, or Weksler.
- 2.2 All thermometers and pressure gauges shall be readable from a standing position on the floor. Mount thermometers in approved wells. Do not make direct contact of base with fluid in pipe. Pressure gauges and thermometers subject to vibration shall be mounted remotely away from vibrating pipe surface, etc. with flexible tubing.
- 2.3 Water thermometers shall be blue-reading spirit liquid-in-glass type with 9" scale, powder coated cast aluminum case and stem socket of length as required by system. Accuracy to be plus or minus 1 scale division. Lens to be plastic. Hot water thermometer shall have a 30°F to 240°F range and chilled water and geothermal water thermometer shall have a 0°F to 120°F range.
- 2.4 Pressure gauges shall be Bourdon Type, circular, 4-1/2" face, black letters on white face graduated in 2 PSI or less and shall be manufactured for service intended. Accuracy to be plus or minus 1%. Water pressure gauges shall have 0 to 100 PSI range.
- 2.5 Provide direct mount Bimetal dial thermometers in HVAC ductwork. Thermometer shall be 3" diameter, with polycarbonate plastic lens and stainless-steel case. Air temperature range shall be 25°F to 125°F.

#### **PART 3 – PRESSURE/TEMPERATURE PORT (PETE'S PLUG – P/T PLUG):**

- 3.1 Provide 1/4" NPT fitting to receive either a temperature or pressure probe, 1/8" OD. Fitting shall be solid brass with two valve cores. Valve core material to be neoprene for temperatures up to 200°F and Nordel for temperatures up to 275°F. Pete's Plugs to have 3" length when installed on insulated pipes and 1-1/2" length for uninsulated pipes. Pete's Plug to be fitted with a cap and gasket, and shall be rated at 1000 PSIG at 140°F.

- 3.2 The installing contractor shall supply the Owner (4) pressure gauges with 1/8" OD probe and (4), five-inch stem pocket testing thermometers rated for 0-220°F water and 4, 50-550°F water thermometers.

**END OF SECTION**

## **SECTION 20 24 00**

### **IDENTIFICATIONS, TAGS, CHARTS, ETC.**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.

#### **PART 2 – TAGS AND CHARTS:**

- 2.1 Provide and install on each concealed valve for all mechanical systems a 1.5" diameter circular bronze or baked phenolic tag fitted to each valve so that it cannot be removed. Each tag shall be embossed consecutively with sequential number identifiers. Number identifiers shall be determined by the Contractor sequentially.
- 2.2 Provide typewritten valve charts indicating each valve identifier, the valves service, normal position and its location. Also furnish one electronic copy on CD in "\*.xls" format. One (1) copy of this chart shall be mounted in suitable frame(s) with clear plastic covers in a conspicuous location in each of the major mechanical rooms. Repeat only main valves which are to be operated in conjunction with operations of more than single mechanical room.
- 2.3 All emergency shutoff valves shall be identified with a permanent engraved tag hung from the valve with 1-inch high lettering. Emergency shutoff valves shall be identified as any valve whose closure could create an emergency condition in the facility (i.e. natural gas, water, domestic hot water, main HVAC valves, etc.).
- 2.4 Label all control panels and disconnect switches with service and equipment served.

#### **PART 3 – PIPING AND DUCTWORK IDENTIFICATION:**

- 3.1 All piping and ductwork installed shall be identified according to the charts hereinafter specified. Provide stenciled markers and arrows indicating direction of flow on all piping and ductwork installed under this contract. Markers and arrows shall be painted on the piping and ductwork using machine cut stencils. All letters shall be sprayed using fast drying lacquer paint. All markers and arrows shall be properly oriented so that descriptive name may be easily read from the floor. Piping and ductwork shall be identified on twelve (12) foot centers. All piping and ductwork shall be minimally identified once above all room ceilings and where it passes thru walls or floors. At the Contractor's option, Setmark or equivalent manufactured marking system may be substituted for field marking.

- 3.2 The following table describes the size of the color field and size of the identification letters which shall be used for pipes of different outside pipe diameters.

<u>Outside Diameter</u>	<u>Label Length</u>	<u>Letter Size</u>
3/4" – 1 1/4"	8"	1/2"
1 1/2" – 2"	8"	3/4"
2 1/2" – 6"	12"	1 1/4"
8" – 10"	24"	2 1/2"
Over 10"	24"	3 1/2"

- 3.3 The following chart describes the pipe service and label identification which shall be used for various pipes.

<u>PIPE</u>	<u>ABBREVIATION</u>
Geothermal Supply	G.S.
Geothermal Return	G.R.
Domestic Cold Water	D.C.W.
Domestic Hot Water	D.H.W.
Recirculated Hot Water	R.H.W.
Natural Gas	NAT.GAS.
Refrigerant Piping	RL/RS
Fire Protection	SPRINKLER

#### **PART 4 – NATURAL GAS PIPING IDENTIFICATION:**

- 4.1 All-natural gas piping within mechanical rooms shall be painted safety orange. Natural gas valves shall be painted red. Piping shall be prepped as required and piping shall be painted with at least two coats of paint or more if required to properly cover the piping. Piping in the kitchen shall be painted black. Exterior gas piping shall be painted to match the building with color as directed by the Architect/Owner.
- 4.2 In addition, natural gas piping and meter loop shall be painted color as selected by Architect.

#### **PART 5 – EQUIPMENT IDENTIFICATION:**

- 5.1 Unless otherwise specified, all equipment shall be identified. The titles shall be short and concise and abbreviations may be used as long as the meaning is clear. In finished rooms and mechanical rooms, equipment shall be identified neatly and conspicuously with engraved black lamacoid plates (or equivalent) with 1" high white letters on the front of each piece of equipment.
- 5.2 All mechanical equipment and associated starters/disconnects shall have the electrical panel number and circuit number identified on a lamacoid plate. Coordinate with the Electrical Contractor.

**PART 6 – DUCTWORK IDENTIFICATION:**

6.1 All ductwork shall be identified as to the service of the duct and direction of flow. Include equipment designator on SA & RA ductwork. The letters shall be at least two inches high and the flow arrow shall be at least six inches long. The letters and flow arrow shall be made by precut stencils and black oil base paint with aerosol can. Concealed ducts also need to be identified.

6.2	<u>DUCTWORK</u>	<u>ABBREVIATION</u>
	Supply Air Ductwork	SA + Equipment Identifier
	Return Air Ductwork	RA + Equipment Identifier
	Exhaust Air Ductwork	EA + Equipment Identifier
	Outside Air Ductwork	OA + Equipment Identifier

**PART 7 – ACCESS THROUGH LAY-IN CEILINGS:**

7.1 Mark each lay-in ceiling panel which is nearest access to air flow damper, with lamacoid labels located on the ceiling grid.

**END OF SECTION**

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## **SECTION 20 25 00**

### **HANGERS, CLAMPS, ATTACHMENTS, ETC.**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 Each Contractor's attention is also directed to Specification Section PIPE, PIPE FITTINGS AND SUPPORT.
- 1.3 This section includes, but is not limited to, furnishing and installing supports, anchors, and accessories for piping, ductwork, equipment, etc. Furnishing and installing shall be by each trade for the completion of their work as directed in this Section.

#### **PART 2 – MATERIALS AND EQUIPMENT:**

##### **2.1 HANGERS, CLAMPS, ATTACHMENTS SCHEDULE:**

- ACCEPTABLE MANUFACTURERS: Grinnell, Elcen, Fee & Mason.
- All hangers, clamps and attachments shall be manufactured products.
- Pipe Rings (2" pipe and smaller) – adjustable swivel split ring or split pipe ring.
- Pipe Clevis (2.5" pipe and larger) – adjustable wrought clevis type.
- Pipe Clevis (All pipe sizes) – steel clevis for insulated pipe.
- Riser Clamps (All pipe sizes) – extension pipe or riser clamp.
- Beam Clamps (All pipe sizes) – malleable beam clamp with extension piece.
- Brackets (All pipe sizes) – medium weight steel brackets.
- Concrete Inserts (All pipe sizes) – wrought or wedge type inserts.
- Concrete Fasteners (All pipe sizes) – self-drilling concrete inserts.
- Rod Attachments (All pipe sizes) – extension piece, rod coupling, forged steel turnbuckle
- U-bolts (All pipe sizes) – standard u-bolt.
- Welded Pipe Saddles (All pipe sizes) – pipe covering protection saddle sized for thickness of insulation.
- Pipe Roll (All pipe sizes) – adjustable swivel pipe roll.
- Protection Saddle (All pipe sizes) – 180-degree coverage, sheet metal pipe protection saddle.
- Hanger Rods (All pipe sizes) – Steel, diameter of hanger threading.
- Concrete Channel Inserts (All pipe sizes) – continuous heavy-duty slot inserts unistrut.
- Adjustable Spot Inserts (All pipe sizes) – continuous heavy-duty spot insert unistrut.
- Miscellaneous steel such as steel angles, rods, bars, channels, etc used in framing for supports, fabricated brackets, anchors, etc. shall conform to ASTM-A-7.

**PART 3 – INSTALLATION:**

- 3.1 Supporting and hanging shall be done so that excessive load will not be placed on any one hanger so as to allow for proper pitch and expansion of piping.
- 3.2 Hangers and supports shall be placed as near as possible to joints, turns and branches.
- 3.3 For concrete construction, utilize adjustable concrete inserts for fasteners. Expansion anchors and power-driven devices may be used when approved in writing by the Architect/Engineer.
- 3.4 Utilize beam clamps for fastening to steel joists and beams. Expansion anchors in masonry construction. Do not support piping or ductwork from bridging or metal decking.
- 3.5 When piping is routed in joists, piping shall be top mounted on trapeze type hangers with each pipe individually clamped to trapeze hanger. Do not support piping or ductwork from bridging angles.
- 3.6 Trapeze hangers are not allowed, unless specifically approved by the Engineer.
- 3.7 Install all miscellaneous steel other than designed building structural members as required to provide means of securing hangers, supports, etc., where piping does not pass directly below or cross structural elements.
- 3.8 Piping shall not be supported by the equipment to which it is connected. Support all piping so as to remove any load or stress from the equipment.
- 3.9 Where piping, etc., is routed vertically, approved riser clamps, brackets or other means shall be utilized at approximately 10'-0" center to center minimum. An approved adjustable base stand or fitting on concrete support base shall be utilized at the base of the vertical run.
- 3.10 Where piping is routed along walls, knee braced angle frames, etc. pipe brackets with saddles, clamps, and rollers mounted on structural brackets fastened to walls or columns shall be used.
- 3.11 Support all ceiling hung equipment with approved vibration isolators.
- 3.12 Where copper tubing is specified, hangers shall be of copper clad type when piping is uninsulated.
- 3.13 Uninsulated piping hung from above shall be supported with ring and clevis type pipe hangers. Uninsulated piping mounted on trapeze (when allowed) and wall bracket type support shall be held in place with U-bolts. U-bolts shall allow for axial movement in the piping.
- 3.14 All insulated piping shall be supported with clevis type and pipe roll hangers. Hangers shall be sized to allow the pipe insulation to pass through the hangers. Install insulation

protection saddles at all hanger locations. Welded pipe saddles shall be installed at all hangers on piping 5" and larger. The pipe saddles shall be sized for the thickness of insulation used. Hangers shall fit snugly around outside of insulation saddles.

- 3.15 Under no conditions will perforated band iron or steel wire driven hangers be permitted.
- 3.16 Support steel and copper piping at a minimum of eight (8) foot intervals for piping 3" and smaller and ten (10) foot intervals for larger piping. Provide additional support at end of the branches and change of direction.
- 3.17 Support plastic pipe at intervals not to exceed four (4) feet and at the end of the branches and at the change of direction and shall be installed as to permit freedom of movement. Vertical piping shall be supported at their bases and all upward movement shall not be restricted. Hangers shall be at least one (1) inch wide and shall not compress, distort, cut or abrade the piping to allow free movement at all times.
- 3.18 Where fireproofing is dislodged/damaged from the building structure due to Contractor's installation of hangers, clamps, etc., it shall be the Contractor's responsibility to repair all dislodged/damaged fireproofing to original fireproofing rating. This shall also include all work performed by their contractor's sub-contractors.
- 3.19 Ensure that all bolts and nuts are tightened.

**END OF SECTION**

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**SECTION 203100**

**TESTING, BALANCING, LUBRICATION AND ADJUSTMENTS**

**PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 The Engineer, or authorized representative, shall be notified by the Contractor twenty-four (24) hours in advance of any tests called for in these Specifications or required by others.
- 1.3 Only after written approval, signed by the Engineer, shall the Contractor apply insulation or paint or allow the work to be furred-in. This written approval, however, does not relieve the Contractor of the responsibilities for any failure during the guarantee period. The expense of all tests shall be borne by the Contractor, along with all temporary equipment, materials, gauges, etc. required for tests.

**PART 2 - HEATING, VENTILATING AND AIR CONDITIONING TESTING:**

- 2.1 The test and balance of this system shall be by a Contractor who employs only the services of a certified AABC or independent NEBB firm whose sole business is to perform test and balance services. The Test and Balance contractor shall report all deficiencies to the Engineer.
- 2.2 The test and balance contractor shall bid directly to the Mechanical Contractor.
- 2.3 Mechanical Contractor shall provide all start-up documents to Test and Balance Contractor prior to any test and balance services.
- 2.4 The Mechanical Contractor shall test all piping before being insulated or concealed in any manner. Where leaks or defects develop, required corrections shall be made and tests repeated until systems are proven satisfactory. Water piping systems shall be subjected to a hydrostatic test of not less than one hundred pounds and shall be proven tight after a twenty-four (24) hour test.
- 2.5 All motors, bearings, etc. shall be checked and lubricated as required during start-up procedures. All automatic, pressure regulating and control valves shall be adjusted. Excessive noise or vibration shall be eliminated.
- 2.6 System balancing, where required, shall be performed only by persons skilled in this work. The system shall be balanced as often as necessary to obtain desired system operation and results.
- 2.7 All fan belts shall be adjusted for proper operation of fans.

- 2.8 Testing shall occur after completion of the ceiling systems installation.
- 2.9 All deficiencies observed by the Test and Balance Contractor shall be reported immediately to the Engineer and Mechanical Contractor.
- 2.10 Refer to Specification Section GEOTHERMAL LOOP SYSTEM for additional requirements.
- 2.11 Refer to Specification Section – CONTROLS – DIRECT DIGITAL for additional requirements.
- 2.12 Refer to Specification Section – GENERAL PROVISIONS – MECHANICAL for startup requirements.
- 2.13 Provide a preliminary test report to the Engineer immediately after the system is air balanced, or any initial phases are balanced. This report may be hand written. Any systems that are not found to operate within the design tolerances by the Test and Balance Contractor shall be immediately be reported to the Engineer via telephone call to attempt to determine a resolution while the Test and Balance Contractor is still on site. Additional compensation will not be accepted for additional trips.
- 2.14 Anticipate visiting the site again after the Engineer has reviewed the report. The Engineer may request up to two (2) additional site visits for onsite troubleshooting where additional measurements may be required.
- 2.15 For the purpose of placing the Heating, Ventilating and Air Conditioning systems in operation according to design conditions and certifying same, final testing and balancing shall be performed in complete accordance with AABC Standards for Total System Balance, Volume Six (2002), for air and hydronic systems as published by the Associated Air Balance Council.
- 2.16 The following systems shall be tested and balanced:
- The supply, return, outside and exhaust air duct systems associated with all OA units and heat pumps. Provide static pressure profiles thru each system. Static pressure profiles shall include all sections from the return duct inlet and supply duct outlet of the heat pump unit. Show accurate representation of return, relief, outdoor and economizer damper locations. On units equipped with exhaust air fans; show location and profile of the exhaust fan.
  - Measure and verify the minimum outside air flow at the minimum OA damper. Measure the resulting differential pressure across the damper and record it on the placard located on the unit.
  - Outside and exhaust air in each room to within 5% of design air flow rate.
  - Heat pump total air flow and discharge and inlet pressures.
  - Hydronic and domestic pumps total water flow.
  - Balance heat pump water-to-water loop, circulating pumps and associated coil water flows.
  - Verify calibrations of the duct static pressure and water pressure sensors for all systems.

- Balance each geothermal wellfield row.
  - Balance each heat pump unit and adjust ECM motor to design airflow. Record inlet and outlet static pressure, including filters. Measure outside air flow at each heat pump.
  - Balance all supply and return air grilles to within 10% of design air flow rate.
  - Balance domestic hot water return system including all balance valves and record settings and flows.
- 2.17 The flushing and purging of the geothermal system shall be witnessed and approved. Refer to Specification Section GEOTHERMAL LOOP SYSTEM and Specification Section PIPE FILLING, CLEANING, FLUSHING, PURGING AND CHEMICAL TREATMENT for additional requirements.
- 2.18 Balance the water flow rate of each domestic hot water recirculating pump. Set the flow rate for each balancing valve in the recirculating hot water system. If flow rates are not indicated, contact the engineer for each balance valve GPM.
- 2.19 Instruments used for testing and balancing of air and hydronic systems shall have been calibrated within a period of six months prior to balancing. All final test analysis reports shall include a letter of certification listing instrumentation used and last date of calibration.
- 2.20 Test and Balance agency shall provide sizing of fan or motor sheaves required for proper balance. The Mechanical Contractor shall purchase and install all sheaves and belts as required. This includes new and existing equipment.
- 2.21 Three (3) copies of the complete test reports shall be submitted to the Consulting Engineer prior to final acceptance of the project. Preliminary test reports shall be submitted when requested.
- 2.22 The Contractor shall provide and coordinate work to provide sufficient time before final completion date so that tests and balancing can be accomplished and provide immediate labor and tools to make corrections when required without undue delay.
- 2.23 The Contractor shall put all heating, ventilating and air conditioning systems and equipment and rangehood system into full operation and shall continue the operation of same during each working day of testing and balancing.
- 2.24 The Test and Balance Contractor shall be present during the Engineer's final inspection of the building, or a separate project review date. The Engineer may request confirmation of the air balance report by asking for new measurements to be taken at that time. Any information in the test and balance report may be asked to be reconfirmed.

**END OF SECTION**

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## **SECTION 21 01 00**

### **FIRE PROTECTION SYSTEM**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 No Contractor, other than those regularly engaged in the installation of approved and franchised automatic sprinkler systems will be considered or approved for the work under this Specification Section. The Contractor shall have not less than five (5) years experience in the fabrication and erection of fire protection systems as specified. The Contractor shall have completed five (5) installations similar and equivalent in scope to the systems specified.
- 1.3 Before submitting bid, examine the Contract Documents, visit the site (if necessary) and become acquainted with all conditions that may, in any way whatsoever, affect the execution of this work. The Contractor shall take their own measurements and be responsible for exact size and location of all openings required for installation of this work. Figured dimensions where indicated are reasonably accurate and should govern in setting out work. Detailed method of installation is not indicated. Where variations exist between described work and approved practice, the Engineer shall be consulted for directive.
- 1.4 It is the intent of the Plans and Specifications to provide a general layout only and locate major equipment, components, piping, etc. Variations in head locations, pipe routing, etc., shall be anticipated by the Contractor and shall be coordinated with all other trades and indicated on the drawings and descriptive literature called for hereinafter. It shall be the express responsibility of the Contractor to provide all required design, materials and equipment and perform all work required to install a complete and approved installation.
- 1.5 All materials and methods shall be in accordance with applicable codes, regulations and/or ordinances and meet approval of local inspection authority and the State Fire Marshal. Also, all work shall comply with the latest editions of the National Board of Fire Underwriters, National Fire Protection Association, OSHA Regulations, the International Building Code, the Life Safety Code, International Mechanical Code and governing building codes. All materials and equipment installed as a part of this work shall be listed by the Underwriters Laboratories, Inc. as approved for fire protection installations.
- 1.6 Where flow and pressure data are available, they are indicated on the project drawings. The Contractor shall independently verify all such information and notify the Engineer of any discrepancies discovered prior to beginning the work. Where no flow information is indicated on the project drawings, the Contractor shall obtain the data and indicate it on the shop drawing submittal. All flow information obtained shall be less than six (6) months old. Piping systems shall be hydraulically sized based on the most conservative

flow information obtained. No adjustments in the contract amount will be allowed for failure of the Contractor to obtain adequate flow information.

- 1.7 The Owner's local insuring agency may review plans prepared and submitted by the Contractor but shall have no authority to make changes once work has begun. Coordinate with the Owner prior to construction.
- 1.8 All work performed under this section shall be accomplished in close harmony with all other trades. All work not so coordinated shall be removed and reinstalled at the expense of the Contractor.
- 1.9 The Contractor shall list the following cost breakdowns, material and labor, on the official project schedule of values:
  - Fire Protection Shop Drawings and Approvals
  - Fire Protection Materials & Labor
  - Fire Protection Record Drawings & Acceptance

## **PART 2 – SCOPE OF WORK:**

- 2.1 Furnish all material, labor, tools, equipment and supervision required for installation of a complete and new fire protection system as indicated on the project drawings and within these specifications. Include all necessary piping, sprinkler heads, test connections, valves, drains, etc.
- 2.2 The Contractor shall provide flushing and sterilization of all water lines in accordance with current Codes, Rules and Regulations and shall make connection to domestic water mains in accord with current rules and regulations of the State Department of Sanitary Engineering and Division of Water.
- 2.3 The Contractor shall obtain and pay for all necessary state, municipal, county, city and other permits and fees and pay all State taxes which are applicable.
- 2.4 All workmanship, equipment and material shall be guaranteed in writing against defects from any cause, other than misuse, for a period of one year from substantial completion.
- 2.5 Upon completion, the Contractor shall submit to the Engineer, a properly completed "Sprinkler Contractor's Certificate Covering Materials and Tests" form.
- 2.6 Upon completion of this work all debris, material, and equipment shall be removed from the building and premises; all piping shall be cleaned ready for finish painting. Do not remove rust inhibitive primer specified hereinafter.

## **PART 3 – SHOP DRAWINGS:**

- 3.1 The Contractor shall prepare and submit to the Engineer, shop drawings including design calculations, detailed catalog cutsheets and layout drawings indicating the proposed automatic sprinkler system. All layouts and drawings shall be closely coordinated by the Contractor with the work of ALL other trades. The shop drawings shall indicate the following items:

- Name and address of Owner, Architect and Engineer.
  - Sprinkler heads including temperature rating.
  - Fire department connection.
  - Detector check valves.
  - Wet pipe alarm valves and wet system specialties.
  - Flanged gate and check valves.
  - Pipe hangers.
  - Supervised O.S & Y valve.
  - Fire Pump, starter/controller and electrical characteristics
  - Make and type of jockey pump and electrical characteristics
  - The post indicator supervisory switch (coordinated with the Fire Alarm Contractor).
  - The main gate valve supervisory switch (coordinated with the Fire Alarm Contractor).
  - The flow switch (coordinated with the Fire Alarm Contractor).
- 3.2 On a set of drawings to the same scale as the drawings accompanying these specifications, indicate:
- Each head location coordinated with lights, diffusers and other ceiling mounted device.
  - Location of all risers, mains, runout lines, etc.
  - Size of all risers, mains, runout lines, etc.
  - Location and type of pipe hangers.
  - All other information required by the Authority Having Jurisdiction providing approval.
- 3.3 The Contractor shall submit these shop drawings to the Engineer through the General Contractor and Architect for their review and approval. The Contractor shall submit the reviewed drawings to the Authority Having Jurisdiction for their review and approval. The Contractor shall incorporate all review comments from the Engineer and the Authority Having Jurisdiction. No work shall be performed onsite until all review processes are complete and updated drawings are on the job site.

#### **PART 4 – EQUIPMENT AND MATERIALS:**

- 4.1 DETECTOR CHECK VALVE: Furnish and install detector check valve as required by the local authority. It shall be listed and approved by Underwriter Laboratories and Associated Factory Mutual Laboratories; 175# working pressure; IBBM; flanged; with tapped bosses each side for by-pass meter trimming; equivalent to Viking, Badger or Grinnell.
- 4.2 The Contractor shall contact the servicing water company and ascertain their policy pertaining to the bypass water meter. If not furnished by water company, the Contractor shall furnish and install the bypass meter and trimming as detailed on the drawings.
- 4.3 FIRE DEPARTMENT CONNECTION: Furnish and install a fire department connection with threads as approved by the local fire department; cast brass polished and chromium plated; with connection sizes and lettering as directed by the local authority having jurisdiction; Viking, Automatic Sprinkler Corporation, or approved equivalent.
- 4.4 WET ALARM VALVES: All alarm valves must be UL and FM approved. Alarm valve shall have a grooved seat design with retarding chamber. Valve shall be rated for 175

- PSI working pressure. Valve shall be provided with external bypass line and drain valve. Reliable, Gem, Grinnell, Star, Viking or approved equal.
- 4.5 FLOW INDICATOR SWITCHES: Furnish and install flow indicator switches as required by NFPA 13. All flow indicator switches shall be UL approved. Coordinate with Fire Alarm System supplier/installer.
- 4.6 TAMPER SWITCHES FOR WATER SHUT-OFF VALVES: Furnish and install tamper switches where required by NFPA 13. All tamper switches shall be UL approved. Coordinate with Fire Alarm System supplier/installer. All tamper switches located in fire protection pits shall be waterproof, capable of operating beneath water and be NFPA approved.
- 4.7 GATE VALVES: 2½" and over; listed and approved by UL and FM; marked SV-FM; 175# working pressure; 1 BBM; OS&Y; flanged; cast iron discs; bronze seat rings; four-point wedging mechanism; equivalent to Mueller, Scott or Lunkenheimer. 2" and under; 150# working pressure; bronze; rising stem; screwed; bronze discs; bronze seat rings; two-point wedging mechanism; equivalent to Jenkins, Scott or Lunkenheimer.
- 4.8 CHECK VALVES: 2½" and over; listed and approved by UL and FM; marked SV-FM; 175# working pressure; 1 BBM; flanged; equivalent to Mueller, Scott or Lunkenheimer. 2" and under; 150# working pressure; bronze; screwed; equivalent to Jenkins, Scott or Lunkenheimer.
- 4.9 INTERIOR PIPE & FITTINGS:
- 4.10 Pipe sizes under 4": CPVC fire sprinkler pipe shall be manufactured from a Type IV, Grade I Chlorinated Polyvinyl Chloride (CPVC) compound with a Cell Classification of 23547 per ASTM D1784. Pipe shall be manufactured in strict compliance with ASTM F442 to SDR 13.5 dimensions, consistently meeting the Quality Assurance test requirements of this standard with regard to material, workmanship, burst pressure, flattening, and extrusion quality. All CPVC fire sprinkler pipe shall be Listed by Underwriters Laboratories for wet pipe systems, and shall carry a rated working pressure of 175 psi @ 150°F. All CPVC fire sprinkler pipe shall be installed in accordance with Georg Fischer Harvel LLC CPVC Fire Sprinkler Piping Products Installation Instructions. National Fire Protection Association (NFPA) Standards 13, 13D, and 13R must be referenced for design and installation requirements in conjunction with the Installation Instructions. All CPVC fire sprinkler pipe shall be manufactured in the USA by an ISO 9001 certified manufacturer and shall be FM and LPCB approved. All CPVC fire sprinkler pipe shall be packaged immediately after its manufacture to prevent damage and shall be stored indoors after production, at the manufacturing site, until shipped from factory. This pipe shall bear the logo of the listing agencies, and shall carry the National Sanitation Foundation (NSF) seal of approval for potable water applications. All CPVC fire sprinkler pipe shall be GF Harvel BlazeMaster® pipe as manufactured by Georg Fischer Harvel LLC or approved equal.
- 4.11 Pipe sizes 4" and larger: Schedule 40 black steel with flanged, welded or victaulic (or similar) type approved fittings.

- 4.12 Do not route sprinkler piping (including drops) directly above any light fixtures. Do not route sprinkler piping near ceiling; hold tight to structure. Where large volumes occur above ceiling route pipe at least 36" above ceiling. The Sprinkler Contractor shall coordinate during design of sprinkler systems to insure these requirements are met.
- 4.13 SPRINKLER HEADS: Tyco, Grinnell, Viking, Reliable: All sprinkler heads shall be fed in a reverse bend arrangement. Sprinkler head degree ratings shall be determined by the area serviced in accord with current Codes and Standard Practices. Types of sprinkler heads shall be as follows:
- Semi-Recessed, Quick Response – Reliable (or equal) Model F1FR-300 semi-recessed automatic sprinkler head. Escutcheon and head shall be white.
  - Upright, Quick Response – Reliable (or equal) Model F1FR Vertical Upright automatic sprinkler head.
  - Sidewall, Quick Response – Reliable (or equal) Model GFR, horizontal sidewall automatic sprinkler head. (to be installed within the residence rooms)
- 4.14 At the Contractor's option, extended coverage sprinkler heads may be used where appropriate.
- 4.15 At the Contractor's option, code approved flexible sprinkler heads may be used where appropriate and in compliance with the installation requirements of these specifications.
- 4.16 Where sprinkler heads are installed in a tile ceiling, they shall be installed in the middle of the tiles, at half or quarter points along the length of the tiles.
- 4.17 CLAMPS AND ANCHORS: Furnish and install approved clamps, as required, at all (45 degree) 1/8 bends, (90 degree) 1/4 bends and flange and spigot pieces to the straight pipe to insure permanent anchorage of all fire lines. Fittings, clamps, clamp rods, nuts, washers, and glands shall be factory zinc-coated.
- 4.18 HANGERS: All piping shall be adequately and permanently supported in an approved manner on approved hangers. Minimally support piping on 8 foot intervals for pipe 3" and smaller; 10 foot intervals for larger piping. Also support within 24" of changes in direction and end of runs.
- 4.19 SLEEVES AND ESCUTCHEON PLATES: Furnish and install sleeves for pipes where piping penetrates masonry walls; exterior wall sleeves to be watertight. Fire and smoke stop all penetrations through fire and smoke walls and coordinate with General Contractor for locations. Furnish and install cast brass chrome plated split ring type escutcheons where piping penetrates walls, ceilings and floors, whether in finished areas or not.
- 4.20 INSPECTION TEST CONNECTIONS & PRESSURE GAUGES: A 1" inspection test connection as required by the Building Code. Discharge shall run to open air. Control valve for test connection shall be installed not over 7' above the floor. A pressure gauge at the inspection. Test connection at each location indicated on the Plans. Pressure gauges shall be 2½" diameter and readable from the floor.

- 4.21 SIGNS: Appropriate code approved and required signs shall be installed on all control valves, drains, inspector's test, etc., indicating the function, installation, etc. Signs shall be neatly affixed with rust inhibitive screws, rivets or where hung from piping; with stainless steel No. 14 AWG wire.
- 4.22 SPRINKLER HEAD CABINET: Furnish and install a cabinet, clearly labeled, with four (4) sprinklers of each type complete with required wrenches. Locate as directed by Engineer. Label "Sprinkler Heads".

**PART 5 – SYSTEM DRAINAGE:**

- 5.1 The entire System except that part which is below grade and will not freeze shall be installed so as to allow 100% drainage.
- 5.2 All sprinkler branch piping shall be installed so as to drain back to the main riser.
- 5.3 Approved 2" drawoff piping shall be provided on sprinkler risers with discharge piping running to nearest floor drain or open air.
- 5.4 Where sprinkler piping is trapped, an approved auxiliary draw-off shall be provided and neatly installed.
- 5.5 All draw-offs shall have a metal tag labeled "Sprinkler Drain".

**PART 6 – INSPECTIONS AND TESTS:**

- 6.1 Furnish all labor, equipment and conduct all required tests in the presence of the Owner and Engineer or designated representative if requested. Coordinate with Owner and Engineer prior to testing.
- 6.2 All interior and exterior piping and devices comprising the fire protection system shall be tested under hydrostatic pressure of not less than 200 PSI and maintained for not less than two (2) hours. Any leaks or cracks developing as a result of these tests shall be repaired to the satisfaction of the Owner.
- 6.3 Upon completion of their work, the Contractor shall submit a written and signed certificate to the Engineer indicating that they performed the above prescribed tests and rectified all malfunctions arising therefrom.

**PART 7 – FIRE PUMP, JOCKEY PUMP AND CONTROLS:**

- 7.1 APPROVED MANUFACTURERS: Aurora, Peerless, ITT A-C,
- 7.2 The pump furnished for fire protection service shall be supplied with the specified electric motor, controls and pump accessory items by the pump manufacturer. The pump, motor and control shall be UL listed and FM approved for fire protection service. The pumping equipment shall be installed as recommended in the National Fire Protection Association (NFPA) Standard 20, Standard for the Installation of Centrifugal Fire Pumps. The fire pump shall also be capable of delivering not less than 150% of rated flow at not less than 65% rated head. The pump shall be furnished with drive, controls and accessories

as indicated. Pump manufacturer shall have unit responsibility for the proper operation of the complete unit assembly as indicated by field acceptance tests.

- 7.3 Each individual pump shall be hydrostatically tested and run tested at the factory prior to shipment. The pump shall be hydrostatically tested at a pressure of not less than one and one-half times the no flow (shut off) head of the pump's maximum diameter impeller plus the maximum allowable suction head but in no case less than 250 PSIG.
- 7.4 A field acceptance performance test shall be conducted upon completion of pump installation. The test shall be made by flowing water through calibrated nozzles, approved flow meters or other such accurate devices as may be selected by the authority having jurisdiction. The test shall be conducted as recommended in NFPA Standard 20 by the installing contractor in the presence of the authority having jurisdiction and with that authority's final approval and acceptance. Failure to submit documentation of factory and field tests will be just cause for equipment rejection.
- 7.5 HORIZONTAL CENTRIFUGAL PUMP: The fire pump shall be of horizontal centrifugal single stage construction specifically labeled for fire service. The pump shall be connected to the fire standpipe and fire protection (sprinkler) system. The suction supply for the fire pump shall be from a public service water main. The pump casing shall be cast iron with 125-pound rating suction and 250 PSI pound rating discharge flanges. The flanges shall be machined to American National Standards Institute (ANSI) dimensions.
- 7.6 FITTINGS: The pump manufacturer shall furnish piping accessory items for the pump installation which will adapt the pump connections to the fire protection system and test connection as follows. Fittings subjected to pump discharge pressure shall be ANSI 250-pound rating. The following fittings subjected to suction pressure shall be ANSI 125-pound rating.
- Eccentric tapered suction reducer.
  - Concentric tapered discharge increaser.
  - Hose valve test head.
  - Hose valves with caps and chains.
  - Pump casing relief valve.
  - Automatic air release valve.
  - Ball drip valve.
  - Suction and discharge pressure gauges.
  - Low suction control valve.
- 7.7 ELECTRIC MOTORS: The pump driver shall be horizontal foot mounted ball bearing induction motor. The size of the motor is scheduled on the drawings. The motor locked rotor current shall not exceed the values stated in NFPA Pamphlet 20. The motor shall be mounted on a steel base common to the pump and shall be connected to the pump with a flexible coupling protected by a suitable guard. The fire pump manufacturer shall accurately align the pump and motor shaft prior to shipment. After field installation but prior to grouting the base, a millwright or similarly qualified person shall check and verify or correct the shaft alignment. The fire pump shall be provided with a SOFT starter.

- 7.8 **ELECTRIC MOTOR CONTROLLERS:** The automatic electric motor controller shall be UL listed and FM approved specifically for fire pump service. Provide fire pump controller with integral open transition type transfer switch to comply with NFPA-20 & NFPA 70. Provide with integral over-current protection and disconnecting means for normal and emergency power feeds to transfer switch. Over-current protection shall be sized per NFPA-20 & NFPA-70. Controller and all components shall be service entrance rated. Controller shall have second utility option for emergency power feed.
- 7.9 **JOCKEY PUMP:** The jockey pump shall have a capacity as scheduled on the drawings. The motor enclosure shall be built to NEMA 56 frame standards. The pump shall have a cast iron frame and adapter fits to maintain axial alignment. The pump shall have threaded suction and discharge connection. The pump shall have mechanical seals. The pump shall be provided with a casing relief per NFPA 20.
- 7.10 **FIRE PUMP TEST CONNECTION:** Crocker 6800 Series with pipe size/number of inlets to match the fire pump capacity. Each outlet shall have a cast brass gate valve with cap and chain. Unit body shall be cast brass. Entire unit shall have a polish chrome finish.

**END OF SECTION**

## **SECTION 22 01 00**

### **PLUMBING SPECIALTIES**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall provide all equipment and specialties complete with trim required and connect in a manner conforming to the State Plumbing Code.
- 1.3 The Contractor shall obtain exact centerline rough-in dimensions between partitions, walls, etc. as required for lay-out of the rough-in work. All work shall be roughed-in so that all exposed piping will be straight and true without bends or offsets.
- 1.4 All equipment and specialties shall be new. All equipment and specialties shall be installed as recommended by the manufacturer.
- 1.5 Prior to final inspection, test by operation at least twice, all equipment. Also, remove all stick-on labels, dirt, grease, other removable stampings, lettering, etc. from equipment and specialties and thoroughly clean same.
- 1.6 All equipment and specialties shall be installed in a neat and workmanlike manner. Unacceptable workmanship shall be removed and replaced at the installing Contractor's cost.
- 1.7 Provide all drainage specialties indicated, specified and/or required to provide complete and acceptable removal of all storm, sanitary, waste, laboratory waste, etc. from the building and into approved receptors. Drainage specialties shall be on non-electrolytic conduction to the material to which they are connected. Drainage specialties shall be installed in a manner so as to ensure no leakage of toxic or odorous gases or liquids and shall have traps and/or backflow preventers where required. Nor shall they allow backflow into other or existing systems.

#### **PART 2 - CLEANOUTS:**

- 2.1 CLEANOUTS: In addition to cleanouts indicated on the drawings, provide cleanouts in soil and waste piping and storm drainage at the following minimum locations:
  - At base of each stack.
  - At fifty (50) foot maximum intervals in horizontal lines.
  - At each change of direction of a horizontal line.
  - As required to permit rodding of entire system.
  - As required by current State Plumbing/Building Codes.

- 2.2 Water closets, mop sinks/basins and other fixtures with fixed traps shall not be accepted as cleanouts.
- 2.3 Cleanouts and/or test tees concealed in inaccessible pipe spaces, walls and other locations shall have an eight (8) inch by eight (8) inch (minimum) access panel or cover plates shall be set flush with finished floors and walls and shall be key or screw driver operable.
- 2.4 Access panels for cleanouts shall be of the Zurn 1460 series or equivalent by Josam or Wade. Where they are not to receive paint, they shall be polished bronze unless otherwise indicated where they are to receive paint or other finishes.
- 2.5 Cleanouts and access panels shall be sized so as to permit the entry of a full-sized rodding head capable of one hundred percent circumferential coverage of the line served.
- 2.6 Provide a non-hardening mixture of graphite and grease on threads of all screwed cleanouts during installation.
- 2.7 Do not install cleanouts against walls, partitions, etc. where rodding will be difficult or impossible. Extend past the obstruction.
- 2.8 In finished walls, floors, etc., insure that cleanouts are installed flush with finished surfaces and, where required, grout or otherwise finish in a neat and workmanlike manner.
- 2.9 EXTERIOR CLEANOUTS (ECO): Provide exterior cleanouts where indicated for all sanitary and storm lines leaving the building within 5'-0" of building perimeter. Permanently locate all exterior cleanouts with 12"x12"x12" solid finished concrete marker slightly above grade in grass areas or flush in concrete or pavement areas. Label "CO". Zurn Z-1400-HD cleanout with tractor cover for exterior locations. Provide concrete supporting pad crowned to shed water.
- 2.10 Cleanouts shall be as manufactured by Zurn, Josam, Wade, Ancon, Jay R. Smith, similar to the following:
- Zurn Z-1440 or Z-1445 cleanout tee at base of exposed stack and at change in direction of exposed lines.
  - Zurn Z-1440 cleanout or Z-1445-1 cleanout tee where stacks are concealed in finished walls.
  - Zurn ZN-1400-T cleanout with scoriated top in finished concrete and masonry tile floors.
  - Zurn ZN-1400-Tx cleanout with square recessed top for VCT and linoleum finished floors.
  - Zurn ZN-1400-Z cleanout with round recessed top for poured floors.
  - Mueller D-731 or D-714, Nibco, Flage or equivalent for cleanouts in copper waste with cover plates and/or access panels listed for other cleanouts.
  - Threaded hex head type cleanouts of same materials as pipe for piping 2" and smaller.

- Zurn cleanout with round top with adjustable retainer for carpet area. Install flush with carpet.

**PART 3 – FLOOR DRAINS:**

- 3.1 FLOOR DRAINS: Provide floor drains at locations indicated and/or as required by State Plumbing/Building Codes. Install in a neat and workmanlike manner. Install floor drains in strict accordance with manufacturer's recommendations and the State Plumbing and Building Codes. Coordinate locations with General Contractor to insure floor pitch to drain where required.
- 3.2 Insure by coordination with the General Contractor that spaces served with floor drains on all floors above the lowest level have a water seal extending at least three (3) inches from the floor. Also, for these locations, provide a 36"x36", four (4) pound sheet lead flashing sheet and clamping collar or a 30 mil chlorinated polyethylene shower pan liner. Lead pans shall be given a heavy coat of asphaltum on bottom and sides before installation and a heavy coat on any exposed surfaces. After installation, provide one ply of fifteen (15) pound roofing felt beneath each pan.
- 3.3 The floor drains shall be Zurn, Josam, Smith, Wade, Watts Drainage, Ancon, similar to the following:
- FD-1 - Zurn, ZN-415 floor drain with 6"dia. nickel bronze strainer, Type "B", dura-coated cast iron body with bottom 3" outlet.
  - FD-2 - Zurn, ZN-511 floor drain with 9"dia. nickel bronze strainer, dura-coated cast iron deep sump with 4" bottom outlet, seepage pan and sediment bucket. Sure Seal Model SS preassembled Inline Floor Drain Trap Sealer. 2", 3", or 4" as scheduled. Commercial grade ABS plastic housing and neoprene rubber diaphragm with 1 soft rubber sealing gaskets. Floor rating ASSE – 1072 AF-GW.
  - FD-3 - Zurn, ZN-511 floor drain with 9"dia. nickel bronze strainer, dura-coated cast iron deep sump with 4" bottom outlet, seepage pan and sediment bucket. Provide with trap primer connection.
  - FD-4 - Zurn, Z9A-FD1-3-VP vandal-proof floor drain with 5-3/16" dia. polished stainless steel strainer, polypropylene body and 3" bottom outlet.
  - FS-1 - Zurn, ZN-1900 floor drain cast iron body with white acid resisting porcelain enamel interior and top, anti-splash interior bottom dome strainer, 6" depth and 4" outlet.

**PART 4 – ROOF DRAINS:**

- 4.1 ROOF DRAINS: Provide roof drains at locations indicated within the Contract Documents. Install in a neat and workmanlike manner. Install roof drains in strict accordance with manufacturer's recommendations and the State Plumbing and Building Codes. Coordinate locations with General Contractor to ensure pitch to drain.
- 4.2 Provide roof drains with accessories as required to match roof construction. Provide water tight seal at the connection of the body to the dome, to prevent roof water from entering into the body.
- 4.3 Adjust all water level regulators for overflow roof drains in the field.

- 4.4 Locate downspout nozzles in locations as directed by the Architect.
- 4.5 The roof drains shall be Zurn, Josam, Smith, Wade, Watts Drainage, Ancon, similar to the following:
- RD-1 - Zurn ZC-100-DP 4" outlet roof drain, sump receiver, deck plate, cast iron dome strainer.
  - RD-1A - Zurn, ZC-100-AW-C 4" outlet with aluminum dome, adjustable water level regulator, under deck clamp, cast iron body.
  - RD-2 - Zurn ZC-100-DP 6" outlet roof drain, sump receiver, deck plate, cast iron dome strainer.
  - RD-2A - Zurn, ZC-100-AW-C 6" outlet with aluminum dome, adjustable water level regulator, under deck clamp, cast iron body.
  - RD-3 - Zurn ZC-100-DP 8" outlet roof drain, sump receiver, deck plate, cast iron dome strainer.
  - RD-3A - Zurn, ZC-100-AW-C 8" outlet with aluminum dome, adjustable water level regulator, under deck clamp, cast iron body.
  - OSD-1 - Zurn, ZARB-199-SS 4" outlet downspout nozzle. All rough bronze body, threaded inlet and decorative face of wall flange and outlet nozzle, with removable stainless-steel screen.
  - OSD-2 - Zurn, ZARB-199-SS 6" outlet downspout nozzle. All rough bronze body, threaded inlet and decorative face of wall flange and outlet nozzle, with removable stainless-steel screen.
  - OSD-3 - Zurn, Z ZARB-199-SS 8" outlet downspout nozzle. All rough bronze body, threaded inlet and decorative face of wall flange and outlet nozzle, with removable stainless-steel screen.

**PART 5 – FREEZEPROOF WALL HYDRANTS:**

- 5.1 FREEZEPROOF WALL HYDRANTS: Provide code approved wall hydrants at each location indicated in a neat and workmanlike manner. Affix tight to walls and insure that the feed piping is on the heated side of the building insulation blanket. Provide all water supply specialties indicated, specified and/or required for the complete installation. Install in accordance with the manufacturer's recommendations and the Building Code. Where required by the State Plumbing Code, install code approved vacuum breakers in each water supply specialty.
- 5.2 Wall hydrants shall be Zurn 1320 or equivalent, 3/4", with half-turn ceramic cartridge, encased, flush, non-freeze, anti-siphon, automatic draining wall hydrant with key lock and combination backflow preventer/vacuum breaker.
- 5.3 Mount all wall hydrants at least twenty (20) inches above finished exterior grade. Where this is not possible or practical, contact Engineer for direction.
- 5.4 Turn over for each hydrant, an operator key in an envelope labeled "Exterior Wall Hydrants" to Owner upon completion of the project. Where hydrants have lockable boxes, turn over an operator key for each in an envelope labeled "Exterior Wall Hydrant Locks" to Owner upon completion of project.

**PART 6 – INTERIOR HOSE BIBBS AND DRAIN VALVES:**

- 6.1 HOSE BIBBS AND DRAIN VALVES: Provide code approved hose bibbs and drain valves at each location indicated in a neat and workmanlike manner. Affix hose bibbs tight to walls. Provide all water supply specialties indicated, specified and/or required for the complete installation. Install in accordance with the manufacturer's recommendations and the Building Code. Where required by the State Plumbing Code, install code approved vacuum breakers in each water supply specialty.
- 6.2 HOSE BIBBS (HB): Provide code approved hose bibbs with vacuum breakers and male threaded spouts at each location indicated (toilet rooms, mechanical rooms, etc.). The hose bibbs shall be Woodford Model 24 (or equal) with loose key handle polished chrome finish, brass construction. Hose bibbs shall be mounted at eighteen (18) inches above finished floor. Do not install hose bibbs in spaces which do not have floor drains. Do not install hose bibbs in ADA accessible toilet stalls.
- 6.3 DRAIN VALVES: Install 3/4-inch bronze body drains, similar and equivalent to Nibco, No. 72 or 73, as indicated and at the following locations:
- At the low point and isolatable section of the plumbing system.
  - At each low point and isolatable section of the hydronic system.
  - At each isolatable pipe section.
  - At each water heater.
  - At each storage tank.
  - At each heat pump.
  - At each pump suction.
  - Install a code approved vacuum breaker where installation on to domestic water system.

**PART 7 – WATER HAMMER ARRESTORS (WHA):**

- 7.1 WATER HAMMER ARRESTORS (WHA): Provide water hammer arrestors at each location indicated and/or as required to eliminate hydrostatic on the domestic water system. Install in an accessible location and in a neat and workmanlike manner. Provide all water supply specialties indicated, specified and/or required for the complete installation. Install in accordance with the manufacturer's recommendations and the Building Code. Where required by the State Plumbing Code, install code approved vacuum breakers in each water supply specialty.
- 7.2 Water hammer arrestors shall be Zurn, Z-1700, Shoktrol, Smith, Josam, Wade or equivalent. Water hammer arrestors shall be stainless steel, bellows type. Field fabricated capped cylinders shall not be acceptable. Provide insulating unions where arrestors are of dissimilar material from the piping served (unless piping is non-conducting, such as ABS or PVC).
- 7.3 MULTIPLE FIXTURES – BRANCH LINE LESS THAN 20' LONG: The preferred location for a Zurn Shoktrol is at the end of the branch line between the last two fixtures served when the branch lines do not exceed 20' in length, from the start of the horizontal branch line to the last fixture supply on this line.

7.4 MULTIPLE FIXTURES – BRANCH LINE MORE THAN 20’ LONG: On branch lines over 20’ in length, use two Shoktrols whose capacities total the requirement of the branch. Locate one unit between the last and next to last fixture and the other unit approximately midway between the fixtures.

7.5 Provide at least one water hammer arrestor at all quick acting valve locations including:

- Clothes Washers – Type “A”
- Commercial Dishwashers – Type “B”
- Sterilizers – Type “B”
- Mop Basins, downstream of check valves – Type “A”
- Flush valve fixtures – Type “B”, each toilet room with 1-3 flush valve fixtures shall have its own Type “B” water hammer arrestor.

7.6 ARRESTOR SCHEDULE:

	Zurn Model	Fixture	P.D.I.
Mark	Z-1700	Units	Size
Type “A”	#100	1-11	A
Type “B”	#200	12-32	B
Type “C”	#300	33-60	C
Type “D”	#400	61-113	D

**PART 8 - OTHER SPECIALTIES:**

8.1 VACUUM BREAKERS AND BACK FLOW PREVENTERS: Where required by the Building Code, whether indicated or not, provide approved vacuum breakers or backflow preventers at the following locations.

- Where domestic water system connects to a limited area fire protection system.
- Where domestic water system connects to hydronic system.
- At any threaded hose tap on the domestic water system.
- At all mop basins, provide check valves to the hot and cold-water supply upstream of the faucet.

8.2 ROOF FLASHINGS: All plumbing vents or other plumbing passing thru the roof shall be flashed as approved by the State Plumbing and Building Codes and as recommended by the roofing manufacturer and/or Contractor.

**END OF SECTION**

**SECTION 22 02 00**

**PLUMBING FIXTURES, FITTINGS AND TRIM**

**PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall provide all fixtures complete with trim required and connect in a manner conforming to the State Plumbing Code.
- 1.3 The Contractor shall obtain exact centerline rough-in dimensions between partitions, walls, etc. as required for lay-out of the rough-in work. All work shall be roughed-in so that all exposed piping will be straight and true without bends or offsets.
- 1.4 All fixtures and trim shall be new. All fixtures and trim shall be installed as recommended by the manufacturer. All fixtures shall be set level and true and shall be grouted into finished walls, floors, etc. in a neat and workmanlike manner with an approved waterproof non-yellowing grout for such service. All fixtures and trim shall be installed in a neat and workmanlike manner. Unacceptable workmanship shall be removed and replaced at the installing Contractor's cost. Pay particular attention to flush valves and bracket concealed portion to building structure during rough-in. Loose, shaky flush valves, lavatories, etc. shall not be acceptable.
- 1.5 Handicapped accessible fixtures shall be mounted as recommended by the Building Code and ADA. Special Note for Handicap Grab Rails: Coordinate top of shower valves, flush valves, flush tank, etc., with location of grab rails as shown on the architectural plans. The Contractor shall install all items to allow for installation, removal and service without removal of the grab bar.
- 1.6 Fixture seats shall be Church model 2155CTJ, elongated open front less cover w/ JUST-LIFT, STA-TITE check hinge and DuraGuard Antimicrobial Agent, or approved equal.
- 1.7 All exposed piping, stops, traps, tailpieces, etc. shall be code approved chrome plated brass unless otherwise indicated or specified. Where acid resistant piping is indicated on the drawing or the specifications, all piping and ancillary components from the sink/lavatory to dilution basin shall be acid resistant as specified and required by code.
- 1.8 Water supplies shall connect through walls with stops and chrome plated escutcheons with set screws. In general, furnish drinking fountains, wall-hung lavatories and hose bibbs with manual loose key stop valves. For all other fixtures, furnish with manual permanent-key stop valves (i.e. sinks in casework, etc.). When in doubt, contact Engineer prior to installation.

- 1.9 Coordinate all stainless steel sinks with architectural casework shop drawings for appropriate fit. Do not order sinks until this has been coordinated. Change Orders will be immediately rejected for lack of coordination during construction.
- 1.10 Test for appropriate operation at least twice, ALL fixtures and trim including hands-free trim. Open all faucets and allow to run for fifteen (15) minutes, then remove all faucet aerators and thoroughly clean until smooth flow is obtained. Test by operation at least twice, adequate flow of water at flush valves including appropriate adjustment of hands-free devices, faucets including appropriate adjustment of hands-free devices, hose bibbs, fixture drains, shower heads, etc.
- 1.11 Remove all stick-on labels, dirt, grease, other removable stampings, lettering, etc. from plumbing fixtures and thoroughly clean same.
- 1.12 Provide 1-1/2" P-traps and tailpieces on plumbing fixtures noted below. Any P-traps installed that are not in compliance will be removed and replaced at the contractor's expense.
- 1.13 ACCEPTABLE MANUFACTURERS: Subject to compliance with requirement's manufacturers offering plumbing fixtures and trim which may be incorporated in the work include only the following:
  - 1.13.1 Plumbing Fixtures: American Standard, Kohler, Zurn, Sloan
  - 1.13.2 Plumbing Trim: American Standard, Chicago Faucet, Kohler, Delta Commercial, T&S Brass, Just, Speakman, Zurn Aqua-Spec, Moen Commercial, Symmons
  - 1.13.3 Flush Valves: Sloan, Zurn, Delany
  - 1.13.4 Stainless Steel Sinks: Elkay, Just, Moen Commercial, Sterling
  - 1.13.5 Mop Basins and Laundry Tubs: American Standard, Eljer, Fiat, Kohler, Mustee, Acorn, Zurn
  - 1.13.6 Water Coolers: Elkay, Haws, Sunroc, Oasis, Halsey Taylor
  - 1.13.7 Showers: Bradley, Symmons, Chicago Faucets, Speakman Company, Powers, Acorn, Aqua Bath, Florestone, Swanstone, Willoughby, Aquarius
  - 1.13.8 Appliance Connection Boxes: Guy Gray, Oatley, Wolverine
  - 1.13.9 Fixture Seats: Bemis, Church, Olsonite
  - 1.13.10 Fixture Carriers: Josam, Kohler, Tyler Pipe, Zurn, Wade, Smith, Watts
  - 1.13.11 Lavatory, Sink, Mop Basin and Laundry Tub Strainers: American Standard, Elkay, Kohler, McGuire., Sloan, Zurn.

- 1.13.12 P-traps, Tailpieces, and Escutcheons: American Standard, Elkay, Kohler, McGuire, Moen Commercial, Sloan, Zurn.
- 1.13.13 P-trap Insulation covering for ADA Fixtures: IPS Corp., McGuire, Plumberex.
- 1.13.14 Water supplies and stops: American Standard, Elkay, Kohler, McGuire, Moen Commercial, Nibco, Sloan, Watts, Zurn,

**PART 2 – PLUMBING FIXTURE SPECIFICATIONS:**

- P-1 Floor Set Flush Tank Water Closet – Residence  
Zurn model Z5530, **1.6 GPF**, vitreous china, close coupled, two-piece, siphon jet water closet with elongated bowl and white open front plastic seat with check hinge and bolt caps.
- P-1A Floor Set Flush Tank Water Closet – Residence - ADA  
Zurn model Z5550, **1.6 GPF**, vitreous china, close coupled, two-piece, siphon jet water closet with elongated bowl and white open front plastic seat with check hinge and bolt caps. Mount seat at 18" A.F.F.
- P-1B Floor Set Flush Valve Water Closet - Public  
Zurn model Z5655-BWL, vitreous china, 15" high siphon jet, elongated bowl, china bolt caps and white open front plastic seat with check hinge. Water closet flush valve shall be as follows:  
- Manual flush valve shall be Zurn model Z6000-WS1, 1.6 GPF
- P-1C Floor Set Flush Valve Water Closet – Public - ADA  
Zurn model Z5665-BWL1, vitreous china, 18" high, siphon jet, 1-1/2" top spud, elongated bowl, china bolt caps and white open front plastic seat with check hinge. Install flush valve on "open" side of water closet. Water closet flush valve shall be as follows:  
- Manual ADA flush valve shall be Zurn model Z6000-WS1. **1.6 GPF**. Top of flush valve handle shall be a maximum of 31-1/4" A.F.F.
- P-2 Countertop Lavatory - Residence  
Zurn model Z5114 20"x17" vitreous china lavatory with oval basin, front overflow and 4" center faucet holes. Provide lavatory drain with integral perforated strainer, 3/8" angle rigid supplies with stops and **1-1/2" P-trap and tailpiece**. Lavatory trim shall be as follows:  
- Single handle faucet shall be Zurn model Z81000-3M with polished chrome-plated cast brass faucet body on 4" centers with single lever control. Furnish with **1.5 GPM** vandal-resistant aerator.
- P-2A Countertop Lavatory – Residence - ADA  
Zurn model Z5114 20"x17" vitreous china lavatory with oval basin, front overflow and 4" center faucet holes. Provide lavatory drain with integral perforated strainer, 3/8" angle rigid supplies with stops and **1-1/2" P-trap and tailpiece**. Install insulation on the supply lines and P-trap similar to Brocar "Trap Wrap" vinyl plastic covering per ADA Standards. Mounting height to be per ADA. Lavatory trim shall be as follows:

- Single handle faucet shall be Zurn model Z81000-3M with polished chrome-plated cast brass faucet body on 4" centers with single lever control. Furnish with **1.5 GPM** vandal-resistant aerator.

P-2B Countertop Lavatory – Public - ADA

Zurn model Z5114 20"x17" vitreous china lavatory with oval basin, front overflow and 4" center faucet holes. Provide lavatory drain with integral perforated strainer, 3/8" angle rigid supplies with stops and **1-1/2" P-trap and tailpiece**. Install insulation on the supply lines and P-trap similar to Brocar "Trap Wrap" vinyl plastic covering per ADA Standards. Mounting height to be per ADA. Lavatory trim shall be as follows:

- Single handle faucet shall be Zurn model Z81000-3M with polished chrome-plated cast brass faucet body on 4" centers with single lever control. Furnish with **0.5 GPM** vandal-resistant aerator.

P-2C Lavatory – Wall-hung, Backsplash – ADA Compliant

Zurn model Z5344, 20"x18" vitreous china lavatory with backsplash, rectangular basin, splash lip, front overflow, and 4" center faucet holes. Provide with concealed arm support and wall carrier. Provide lavatory drain with integral perforated strainer, 3/8" angle rigid supplies with stops and **1-1/2" P-trap and tailpiece**. Install insulation on the supply lines and P-trap similar to Brocar "Trap Wrap" vinyl plastic covering per ADA Standards. Mounting height to be per ADA. Lavatory trim shall be as follows:

- Single handle faucet shall be Zurn model Z81000-3M with polished chrome-plated cast brass faucet body on 4" centers with single lever control. Furnish with **0.5 GPM** vandal-resistant aerator.

P-3 Shower - Residence

Best Bath model 4LBS4836 and shall meet ANSI Z124.2. The enclosure shall have dimensions of 48"W x 36"D x 82.5"H. The shower enclosure shall be installed in strict accordance with manufacturer's requirements. If shower is not installed securely, or if the shower has movement while standing on floor, the entire shower enclosure shall be removed and reinstalled properly at contractor's cost. Shower drains to be glued, not compression type. Provide with the following accessories: 1" stainless steel curtain rod, 10 oz. shower curtain with metal hooks, 2" cast brass drain with chrome strainer, recessed fluorescent light fixture.

Provide Zurn Z7300-SS-MT or equal pressure balancing mixing valve with quarter turn stops. Provide Zurn Z7000-i6, institutional **2.0 GPM** shower head with volume control.

P-3A Tub/Shower – Residence - ADA

Aquarius (praxis) Model MP 4836 and shall meet ANSI Z124.2. The shower enclosure shall be installed in strict accordance with manufacturer's requirements. If the shower is not installed securely, or if the shower has movement while standing on floor, the entire shower enclosure shall be removed and reinstalled properly at contractor's cost. Shower drains to be glued, not compression type. Provide with the following accessories: grab bars, 1" stainless steel curtain rod, 10 oz. shower curtain with metal hooks, 2" cast brass drain with chrome strainer; glued type, not compression, and recessed fluorescent light fixture.

Provide Zurn Z7302-SS-MT-DV2P-HW6 or equal pressure balancing mixing valve with quarter turn stops. Provide Zurn **2.0 GPM** shower head, tub diverter, mounting sliding bar, hand held shower and hose, tub spout.

P-3B Shower, 30"x60" Handicap – Enclosure and Fitting Set

Aquarius (Praxis) Model MP 6232, 5 piece sectional shower. Shower and installation to be in compliance with ADA. The shower enclosure shall be installed in strict accordance with manufacturer's requirements. If shower is not installed securely, or if the shower has movement while standing on floor, the entire shower enclosure shall be removed and reinstalled properly at contractor's cost. Provide with the following accessories: grab bars and foldable seat, 1" stainless steel curtain rod, 10 oz. shower curtain with metal hooks, 2" cast brass drain with chrome strainer, recessed fluorescent light fixture. Provide with collapsible dam.

Provide Zurn Z7300-SS-MT-HW6 or equal pressure balancing mixing valve with quarter turn stops. Provide Zurn **2.0 GPM** hand held shower head, 60" flexible metal hose, mounting sliding bar.

P-4 Urinal

Zurn model Z5755-U vitreous china, wall-hung, **1.0 GPF** urinal with 3/4" top spud and concealed wall hanger brackets. Urinal flush valve shall be as follows:

- Manual flush valve shall be Zurn model Z6003-WS1.

P-4A Urinal – ADA

Zurn model Z5755-U vitreous china, wall-hung, **1.0 GPF** urinal with 3/4" top spud and concealed wall hanger brackets. Mounting height shall be per ADA. Urinal flush valve shall be as follows:

- Manual ADA flush valve shall be Zurn model Z6003-WS1. Install per ADA requirements.

P-5 Double Compartment Sink – 29"x18"

Elkay LRAD-2918, compartment stainless steel sink, 29" x 18", 5.5" Depth each bowl, 18 gauge with 3-hole, 8" center faucet punching. Provide with rear outlet back outlet, basket strainer, chrome supply stops, tailpiece, 17 gauge **1-1/2" P-trap and tailpiece.** drain and escutcheons. Sink trim shall be as follows:

- Gooseneck faucet to be Z812A1-XL, with swing spout, **1.5** gpm aerator.

P-6 ELECTRIC WATER COOLER – 2 station with bottle filler.

Elkay Model EMABFTL8WSLK, with bottle filler, 2 station, electric water cooler; mechanically activated, 8.0 GPH of 50 deg F water at 90 deg F room temperature and 80 deg F entering water; stainless steel basin, and shroud. Provide with cane apron. 1/5 HP compressor; 115/1phase/60 HZ.

P-7 Mop Basin

Fiat MSB-24 24, 24" x 24" 10" high molded stone mop service basin in #231 white drift color and #874, 3" drain, Provide Chicago Faucet model 897-CP faucet, #832-AA hose and hose bracket, #889-CC mop hanger and #E-77-AA vinyl bumperguard. Provide with

MSG stainless steel wall guards. Provide check valves on the hot and cold water supplies to the faucet.

P-8 Single Compartment Floor Mounted Laundry Tub

Fiat SF-1F – 20" x 24" molded stone laundry tub supported by white baked enamel steel angle legs with leveling feet. Provide with Chicago Faucets 895-219736AB deck type faucet with 8" centers. Also provide with integral strainer, 3/8" angle rigid supplies with stops and P-trap.

P-9 Washing Machine Connection Box

Guy Gray Model #WB200HA, 2" drain outlet, 16 gauge steel with epoxy finish and integral water hammer arrestors. Field paint exposed portions of box to match adjacent wall surfaces.

P-10 Ice Maker Connection Box

IPS Corporation Water-Tite mini round ice maker outlet box with integral water hammer arrestor and preloaded nails. Connect cold water supply line to water supply at adjacent sink. Field paint exposed portions of box to match adjacent wall surfaces.

**END OF SECTION.**

## **SECTION 22 03 00**

### **PLUMBING EQUIPMENT**

#### **PART 1 – GENERAL:**

- 1.1 All plumbing equipment shall comply with the latest provisions of ASHRAE standard 90 and all provisions of the International Energy Conservation Code.

#### **PART 2 - WATER HEATERS:**

- 2.1 HIGH EFFICIENCY WATER HEATERS (WH-1):
- 2.2 ACCEPTABLE MANUFACTURERS: AO Smith, State and Lochinvar.
- 2.3 The water heater(s) shall be of the seamless glass lined steel tank construction in which the glass coating is applied to the water side surfaces of the tank after the tank has been assembled and welded. The condensing flue coil shall be coated on the flue gas side with acid resistant glass lining designed for use in condensing heaters. The heater(s) shall be suitable for sealed combustion direct venting using a 4" diameter PVC air intake pipe and 4" diameter PVC exhaust pipe for a total distance of 80' equivalent feet of vent and 80' equivalent feet of intake. The heater shall be factory assembled and tested. The power burner shall be of a design that requires no special calibrations on start up. The heater(s) shall be approved for 0" clearances to combustibles. The control shall be an integrated solid state temperature and ignition control device with integral diagnostics, LED fault display capability and a digital display of temperature settings. The tanks shall be foam insulated and equipped with a ASME rated temperature pressure relief valve. The water heater shall be UL listed and exceed the minimum efficiency requirements of ASHRAE/IES 1999.
- 2.4 Install water heaters on rubber/cork isolation pads.
- 2.5 Turn over two spare igniters per water heater to Owner.
- 2.6 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize startup sheets provided by the manufacturer. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for additional requirements.
- 2.7 Provide four (4) hours of onsite training for this system. All training to occur after building completion. System shall function properly and O&M staff shall be able to operate the system prior to turnover.

**END OF SECTION**

## **SECTION 23 01 00**

### **PUMPS**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 Electric motors shall be furnished with the pumps and shall be of the size and type scheduled or otherwise specified. All motors shall be UL labeled and shall comply with applicable NEMA standard. Motors to be high efficiency type. Refer to Specification Section – ELECTRIC MOTORS, ETC.
- 1.3 Shop drawings shall be submitted as required and shall include complete pump specifications, installation and start-up instructions, current and accurate pump performance curves with the selection points clearly indicated, maintenance data and spare parts lists.
- 1.4 Pumps shall be factory tested, cleaned and painted prior to shipment. Size, type, capacity and electrical characteristics are listed in the pump schedule.
- 1.5 Insofar as possible, all pumps shall be by the same manufacturer.

#### **PART 2 – END SUCTION BASE MOUNTED PUMPS (P-1A & P-1B):**

- 2.1 End Suction Base Mounted Pumps shall be Series 1510 as manufactured by Bell & Gossett or equal by Taco, Armstrong, Patterson.
- 2.2 Pumps shall be base mounted, single stage, end suction design with a foot mounted volute to allow servicing of the impeller and bearing assembly without disturbing piping connection. Pump volute shall be Class 30 cast iron with integrally cast pedestal support feet. The impeller shall be cast bronze enclosed type, dynamically balanced, keyed to the shaft and secured by a locking capscrew.
- 2.3 The liquid cavity shall be sealed off at the pump shaft by an internally-flushed mechanical seal with ceramic seal seat and carbon seal ring, suitable for continuous operation at 225°F. A replaceable bronze shaft sleeve shall completely cover the wetted area under the seal.
- 2.4 Baseplate shall be of structural steel or fabricated steel channel with fully enclosed sides and ends, and securely welded cross members. Grouting area shall be fully open. A flexible type, center dropout design coupler, capable of absorbing torsional vibration, shall be employed between the pump and motor. Coupler shall be shielded by a coupler guard securely fastened to the base. Coupler shall allow for removal of pump's wetted

- end without disturbing pump volute or movement of the pump's motor and electrical connections.
- 2.5 Provide all pumps with neoprene couplers. EPDM shall not be acceptable.
  - 2.6 High efficiency motor shall meet NEMA specifications and shall be of the size, voltage and enclosure called for on the plans. Pump and motor shall be factory aligned, and shall be realigned by contractor after installation. Each pump shall be factory tested per Hydraulic Institute standards. It shall then be thoroughly cleaned and painted with at least one coat of high-grade machinery enamel prior to shipment.
  - 2.7 Provide shaft guard with slotted window. Guard to be removable. Guard to meet ANSI B15.1, Section 8 and OSHA 1910.219 requirements.
  - 2.8 Align pump and motor shafts and piping connections after setting them on foundations, after grout has been set and foundation bolts have been tightened, and after piping connections have been made.
  - 2.9 Comply with pump and coupling manufacturers' written instructions.
  - 2.10 A qualified representative of the pump supplier shall perform the pump alignment prior to start-up of any base mounted separately coupled pump. Adjust alignment of pump and motor shafts for angular and parallel alignment by 1 of 2 methods specified in the H.I.'s Standards for Centrifugal, Rotary & Reciprocating Pumps, "Instructions for Installation, Operation and Maintenance."
  - 2.11 After alignment is correct, tighten foundation bolts evenly but not too firmly. Fill base plate completely with non-shrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.
  - 2.12 Alignment Tolerances: According to manufacturer's recommendations, but no more than  $\pm .005"$  in the parallel and angular planes. Provide written report to Engineer and Owner from pump supplier indicating alignment procedure and readings from each pump installation

**PART 3 – PERMANENTLY LUBRICATED INLINE PUMP (DP-1):**

- 3.1 The pumps shall be of the horizontal permanently lubricated type, specifically designed for quiet operation. Suitable for 225 degrees F operation at 150 PSIG working pressure.
- 3.2 The pumps shall have a solid high-strength alloy steel shaft supported by XL11 permanently lubricated sealed precision bearings. Bearings are to be permanently oil lubricated. Pump shaft shall connect to a non-metallic Noryl impeller.
- 3.3 Pump shall have integral stainless steel face plate and double sided stainless steel neck rings for increased life and seasonal start-up capabilities.
- 3.4 Pump volute shall be of cast bronze or stainless steel for domestic water systems. The connection style on bronze pumps shall be flanged.

- 3.5 The motor shall be isolated from circulating fluid through use of a carbon/silicone seal attached on a stainless steel shaft sleeve.
- 3.6 Motors shall be of an Open Drip-Proof design and shall be non-overloading at any point on the pump curve. Motors shall be UL and CSA listed.
- 3.7 Pump shall be of a maintenance free design and be capable of operating in variable speed (varying voltage) applications.
- 3.8 Pump manufacturer shall be ISO-9001 certified.
- 3.9 Pump shall be manufactured by Bell & Gossett or Taco or approved equal.

**END OF SECTION**

## **SECTION 23 02 00**

### **HVAC EQUIPMENT**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 The Contractor shall provide in complete working order the heating, ventilation and air conditioning equipment located as indicated and installed, connected and placed in operation in strict accordance with the manufacturer's recommendations. All equipment shall be factory painted and, where applicable, factory insulated and shall, where such standards exist, bear the label of the Underwriters Laboratory.
- 1.3 All Contractors and Vendors providing a bid for this project shall review the Plans and Specifications and determine any modifications and/or adjustments necessary relative to the proposed equipment and materials with specific manufacturer's installation requirements. Include in the bid any necessary installation methods, features, options, accessories, etc. necessary to install the proposed equipment and materials, regardless of whether used as basis of design or being offered as a substitution in accordance with the specific manufacturer's installation requirements whether specifically detailed or not within the Plans and Specifications.
- 1.4 All equipment, material and labor warranties shall be furnished by the equipment supplier/vendor. All warranties begin on the date of Substantial Completion. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for special warranty requirements.
- 1.5 Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for minimum required Schedule of Values breakdown.
- 1.6 Review the Specification Section – REQUIRED SHOP DRAWINGS, ETC., and provide all documentations called for therein.
- 1.7 Each subcontractor shall be responsible for their own completion of System Verification Checklists/Manufacturer's Checklists. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for additional requirements. Factory startup is required for all HVAC equipment. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians and shall complete and submit start-up reports/checklists. This shall include the following:
  - Heat Pumps
  - Packaged Outside Air Units
  - Variable Frequency Drives
  - Ductless Split Systems

- 1.8 All HVAC equipment shall comply with the latest provisions of ASHRAE Standard 90.1 and all provisions of the International Energy Conservation Code.
- 1.9 Ensure that the equipment that is proposed to be furnish may be installed, connected, placed in operation and easily maintained at the location and in the space allocated for it.
- 1.10 The contractor and vendor shall confirm connection sides for each piece of equipment specific to this project.
- 1.11 Determine from the Bid Documents the date of completion of this project and insure that equipment delivery schedules can be met so as to allow this completion date to be met.
- 1.12 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected and approved systems. Claims for additional cost or change orders will immediately be rejected. Refer to Specification Section - ELECTRIC MOTORS, ETC. for additional requirements. All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.
- 1.13 Review the Specification Section - CONTROLS to determine controls, including variable frequency drives, to be furnished. Where manufacturer's temperature controls are specified, they shall be in full compliance with NFPA 90A including automatic smoke shut down provisions.
- 1.14 Review the Specification Section – TESTING, BALANCING, LUBRICATION AND ADJUSTMENTS. For all belt driven equipment, provide final fan and motor sheaves as determined by the air balance contractor during project balancing phase. The mechanical contractor shall install any new sheaves and belts as required for balancing.

**PART 2 – GEOTHERMAL HEAT PUMPS:**

- 2.1 ACCEPTABLE MANUFACTURERS: Daikin, McQuay, Climate Master, Trane, FHP
- 2.2 A 100% complete mockup installation shall be required for a typical unit. This mockup shall be inspected/reviewed by the Engineer prior to installation of other units.
- 2.3 Any mechanical closet dimension modifications or access requirements due to the manufacturer specifics shall be the burden of the approved manufacturer.
- 2.4 Equipment shall be specifically designed for applications within conditioned interior areas. Capacities shall be rated in accordance with ARI for geothermal applications. Equipment shall be ETL or CSA approved. All equipment shall have decals and labels to aid in servicing and indicate caution areas.
- 2.5 Equipment shall be completely factory assembled and tested, piped, internally wired and fully charged with Refrigerant R-410A. Threaded female water inlet and outlet

- connections, threaded female condensate connection, duct collars and all safety controls shall be furnished and factory installed.
- 2.6 A terminal block with screw terminals shall be provided for control wiring. A condensate overflow device shall be factory installed to stop compressor operation if drain pan overflow is imminent. An energy management relay to allow unit control by an external source shall be factory installed.
- 2.7 Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for special warranty requirements.
- 2.8 CASING AND CABINET: The cabinet shall be constructed of galvanized steel and factory painted with ½" fiberglass on interior, discharge duct collar and return collar. Lift-out removable access panels shall be provided for access to the compressor and blower assembly compartments.
- 2.9 DRAIN PAN: The drain pan shall be constructed of stainless steel and insulated to prevent sweating. The bottom of the drain pan shall be sloped on two planes which will direct the condensate to the drain connection. When the unit is installed per the manufacturer's instructions, the drain pan shall be tested as follows: (1) Temporarily plug the drain pan, (2) fill the drain pan with 2" of water or the maximum allowed by the drain pan depth, whichever is smaller, (3) remove the temporary plug and verify the drain pan removes the water within 3 minutes.
- 2.10 COMPRESSOR: The compressor or compressors shall be high-efficiency, hermetically sealed scroll type with internal vibration isolation. Compressor motors shall be equipped with overload protection. Refer to the drawing schedules as multiple compressor types shall be utilized.
- 2.11 AIR-TO-REFRIGERANT HEAT EXCHANGER: The air-to-refrigerant heat exchanger shall be constructed of staggered copper tubes with die formed corrugated aluminum fins mechanically bonded to the tubes. The air-to-refrigerant heat exchanger shall have a working pressure rating of 400 PSIG. Multiple compressor equipment shall provide a single air-to-refrigerant heat exchanger for each compressor.
- 2.12 WATER-TO-REFRIGERANT HEAT EXCHANGER: The water-to-refrigerant heat exchanger shall be of a high quality co-axial coil for maximum heat transfer and insulated to prevent condensation at low temperatures. The copper coil shall be fluted to enhance heat transfer and minimize fouling and scaling. The coil shall have a working pressure of 600 psig on the refrigerant side and 400 psig on the water side.
- 2.13 REVERSING VALVE: The reversing valve shall be a pilot operated sliding piston type with replaceable encapsulated magnetic coil. The reversing valve shall be energized in the cooling cycle.
- 2.14 REFRIGERANT TUBING: Refrigerant tubing shall be constructed of copper. All low temperature refrigerant lines shall be insulated with an elastomeric insulation that has a 3/8" thick wall, flame spread rating of less than 25 and smoke density rating of less than

- 50, as tested in accordance with ASTM-84. The elastomeric insulation shall have a UL 94V-5 rating.
- 2.15 REFRIGERANT METERING: The equipment shall be provided with a thermal expansion valve. This device shall allow operation of the equipment in the range of 25 to 110° F entering fluid temperatures and 40 to 95° F entering air temperatures. The equipment shall only operate with one variable (enter water temperature, entering air temperature, cfm or gpm) at an extreme condition. All other variables must be within the nominal range of operation.
- 2.16 REFRIGERANT SYSTEM SERVICE ACCESS: The equipment shall be provided with factory supplied high- and low-pressure Schrader ports for easy refrigerant pressure or temperature testing.
- 2.17 BLOWER AND MOTOR ASSEMBLY: See Schedules for motor type. The motor shall have permanently lubricated and sealed bearings. All motors shall have internal thermal overload protection. The fan assembly shall be arranged for back, left, or right discharge. The discharge must also be capable of being changed in the field. Removal of the motor and fan wheel shall be made with the assistance of a factory provided orifice ring assembly. This assembly shall attach the wheel and motor to the fan housing providing single service access. Where available, provide one hand-held motor programming module to the Owner to utilize for startup and test and balance.
- 2.18 UNIT CONTROLS – SAFETIES: A factory tested and installed control box shall contain all necessary devices to allow heating and cooling operation of the equipment to occur. These devices shall be as follows: (1) 24 Vac, energy limiting class II transformer. (2) Blower motor controller shall be a 24 Vac relay. (3) Compressor controller shall be a 24 Vac contactor. All three-phase operated equipment shall have a contactor that interrupts all three-phases providing power to the compressor. (4) Electrically operated safety lockout relay. This device shall prevent operation and anti-short cycling of the compressor during adverse conditions of operation. This device may be reset by either a remote thermostat or momentary interruption of power. (5) High pressure switch shall protect the compressor against operation at refrigerant system pressures in excess of 395 PSIG. (6) Low pressure switch shall prevent compressor operation underneath low charge or catastrophic loss of charge situations.
- 2.19 AIR FILTER SYSTEM: The Contractor shall completely assemble an Air Filter System for each unit and install ready to use. Heat pumps 1.5 ton and smaller require one 16"x20"x2" air filter system. 2 ton Heat pumps require one 24"x24"x2" air filter system. 6 ton Heat Pumps require one 48"x24"x2" air filter system (two 24 X 24 filters). Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for Temporary Use of Equipment Requirements and filter quantities.
- 2.19.1 Side Access Filter Housing: Housings shall accommodate required filter sizes listed above x 2" deep flat filters as noted above. Housings shall be factory assembled, have one hinged access door with quick access latches (operable without special tools), and be constructed on 18-gauge aluminized steel minimum.

- 2.19.2 Filters shall be 30% efficient Merv 8, pleated and disposable. Provide Flanders/FFI Pre Pleat 40, 16"x20"x2" and 24"x24"x2" thick or approved equal. The filter pressure drop shall be 0.28" at 500 fpm face velocity. Each filter shall consist of a non-woven cotton and synthetic fabric media, media support grid and enclosing frame. The filter shall be listed by Underwriters' Laboratories as Class 2.
- 2.20 HOSE KIT & PIPING PACKAGE: Hose kits and piping package shall be as scheduled on the drawings. Single piece hose kits shall be provided for hose kits that are 1-1/2" or less in size. Two-piece hose kits shall be provided for hose kits that are 2" and larger in size. Hose kits shall be the pipe runout size, not heat pump connection sizes. No exceptions!
- 2.20.1 Provide a factory-assembled hose kit/piping package for supply and return connections for each heat pump. Kits may be mounted in any direction and shall not require straight sections of pipe either upstream or downstream for proper operation. All hoses shall be equipped with end connections at terminal unit and shall be 24" long. All end connections shall be either permanently crimped swivel ends or butt welded to carbon steel end fittings to meet stated pressure ratings. Operational temperature shall be rated from fluid freezing to 200 degrees F. Minimum burst pressure shall be four times the working pressure. Furnish with field flushing connection fitting. Up to 1-1/4" shall be reinforced, fire retardant EPDM rubber, bonded to the inside wall of braiding. 1 1/2" and larger shall be a corrugated type 321 stainless steel tube.
- 2.20.2 Each supply side (water inlet) hose kit/piping package shall include a single piece Y - valve body for sizes up to 1-1/2" and shall be constructed of hot forged brass with threaded inlets and outlets. 2" and larger sizes shall be two-piece and constructed of ductile iron with threaded inlets and outlets. All valve bodies are suitable for a minimum of 400 PSIG working pressure. Include single pressure/temperature test ports for verifying the pressure differential and system temperature. Include full flow design ball valve with blow out stems for shut off. Strainer shall be Y-type configuration furnished with hose connector blow down valve. Strainer screen shall be stainless steel mesh and easily accessible for cleaning without disconnecting hoses. All valves shall be labeled with flow direction, manufacturer and model number, unit tagging.
- 2.20.3 Each return side (water outlet) hose kit/piping package shall include a single piece Y - valve body for sizes up to 1-1/2" and shall be constructed of hot forged brass with threaded inlets and outlets. 2" and larger sizes shall be two-piece and constructed of ductile iron with threaded inlets and outlets. All valve bodies are suitable for a minimum of 400 PSIG working pressure. Include single pressure/temperature test ports for verifying the pressure differential and system temperature. Include full flow design ball valve with blow out proof stems for shut off. All valves shall be labeled with flow direction, manufacturer and model number, unit tagging. Include automatic flow control valves which shall be factory set to rated flow and shall automatically control the flow to within 10% of the rated value subject to the operating parameters of 2-80 psid, fluid freezing to 225°F, 2-7 fps. Also provide a three-wire, two-way, two-position control valve with actuator. Actuator shall be field installed by the TCC.
- 2.21 EQUIPMENT START-UP: Prior to utilization of equipment, start-up service shall be performed by factory authorized representative. Utilize startup sheets included in the

Specification Section GENERAL PROVISIONS - MECHANICAL. Refer to Specification Section GENERAL PROVISIONS – MECHANICAL for additional requirements.

- 2.22 Provide eight (8) hours of onsite training for this system. All training shall occur after building completion. Systems shall function properly and O&M staff shall be able to operate the system prior to turnover.

### **PART 3 – OUTSIDE AIR UNITS (OA-1 & OA-2)**

#### **3.1 SPARE PARTS**

- 3.1.1 Furnish to Owner, with receipt, the following spare parts for each energy recovery unit (place in a location determined by the Owner):

3.1.1.1 One set of matched fan belts for each belt-driven fan

3.1.1.2 One set of wheel belts for each energy recovery wheel

3.1.1.3 Three sets of replacement filters.

#### **3.2 ACCEPTABLE MANUFACTURERS**

- 3.2.1 Subject to compliance with requirements, provide energy recovery units of one of the following:

3.2.1.1 Greenheck, Aeon, Innovent, Daikin, Valent, Trane, Xetex

#### **3.3 ENERGY RECOVERY UNITS**

- 3.3.1 General Description: Energy Recovery Ventilator shall be as manufactured by "Greenheck" or approved equal. Provided all specifications are met. Greenheck Model VER equipment is used as basis of design. Performance shall be as scheduled on plans. Units shall be ETL listed and bear the ETL label. Energy transfer ratings shall be ARI Certified. Supply fans shall bear the AMCA Certified Rating Seal for air and sound performance. Performance shall be as scheduled on plans. Outdoor air shall not mix with exhaust air in a common plenum. Exhaust discharge and outside air intake shall not be located on the same side of the roof top units.

- 3.3.2 Casing and Frames: Unit shall consist of a formed and punched integral frame made of G90 galvanized steel. Interior and exterior panels shall be constructed to create a two-inch double wall. All exterior panels exposed to weather shall be a minimum of 10 gage G90 galvanized steel and coated with a polyester urethane powder coat finish (Greenheck's Permatector<sup>TM</sup>). Interior panels will be 18 gage uncoated G90 galvanized steel. Where top panels are joined there shall be an overlapping standing seam to ensure positive weather protection. All metal-to-metal seams shall be factory sealed requiring no caulking at job site. Unit base to be designed for curb mounting and shall overhang the curb for a positive seal against water run-off.

- 3.3.3 Weatherhoods: Weatherhoods shall be of the same finish as the unit. Outdoor air weatherhood shall incorporate a downturned design. Air velocity into the weatherhood shall not exceed a maximum of 500 fpm to prevent water being pulled into the unit. Louvered design - weatherhoods shall be tested in accordance with AMCA Standard 500-L to prevent water penetration up to 3 in/hr at 29 mph. Exhaust air weatherhood shall include an integral backdraft damper and aluminum bird screen.
- 3.3.4 Insulation: Unit casing to be insulated with two-inch-thick fiberglass. Insulation shall meet requirements of NFPA 90A and tested to meet UL 181 erosion requirements. Insulation shall be enclosed in double wall construction and no insulation shall be exposed.
- 3.3.5 Energy Recovery Wheel: Total energy wheel shall provide both sensible and latent energy recovery. Energy transfer ratings must be ARI Certified to Standard 1060 and bear the ARI certification symbol for ARI Air-to Air Energy Recovery Ventilation Equipment Certification Program based on ARI 1060. Ratings "in accordance with 1060" or "through a certification program conducted in accordance to ARI 1060" without certification or bearing the ARI certification symbol are not acceptable. Desiccant shall be silica gel for maximum latent energy transfer. Wheel shall be constructed of lightweight polymer media to minimize shaft and bearing loads. Polymer media shall be mounted in a stainless-steel rotor for corrosion resistance. Because of weight and maintenance issues, single piece aluminum wheel construction not allowed. Wheel bearing shall have a minimum life rating of L(10) 400,000 hrs, equivalent to L(50) 2,000,000 hrs.
- Silica gel desiccant shall be permanently bonded to wheel media to retain latent heat capability after cleaning. Wheels with sprayed on desiccant coatings or with desiccant applied after wheel formation shall not be acceptable. Energy Recovery wheel shall transfer moisture entirely in the vapor phase. Energy Recovery wheel shall be in the upright position.
  - Wheel design shall consist of removable segments (on diameters 36 inches and greater) for ease of service and/or cleaning. Energy Recovery drive belt material shall be high strength urethane and shall be factory installed in a pre-stretched state, eliminating the need for field belt tension adjustment. Link style belts are not acceptable.
- 3.3.6 Access Doors: All components shall be easily accessible through removable doors for exhaust, supply, filter and damper compartments. Energy Recovery wheels (smaller than 58 inches) shall be mounted in a slide-out track for ease of inspection, removal and cleaning.
- 3.3.7 Fans Sections: Exhaust fans shall be centrifugal fans to be double width, double inlet, and forward-curved type. Bearing shall be selected for a minimum L(10) life in excess of 100,000 hours, equivalent to L(50) 500,000 hours, at maximum cataloged operating speeds.
- Supply fans shall be high efficient, 12 bladed, airfoil wheel, centrifugal plenum type, Supply fan shall be AMCA certified and bearing the AMCA symbol for sound and air performance. Fan shall be factory vibration tested in three planes with a tri-axial accelerometer/ Vibration levels shall not exceed 0.15 in/sec peak to peak at the fan rpm.

- All blower wheels shall be statically and dynamically balanced. Ground and polished steel fan shafts shall be mounted in pillow block housing. Bearing shall be selected for a minimum L (10) life in excess of 80,000 hours, equivalent to L (50) 400,000 hours at maximum cataloged operating speeds.
  - Separate motors for exhaust and supply blowers shall be provided. Adjustable sheaves on belt-driven fans with motors less than 10hp shall allow independent balancing of exhaust and supply airflow. Exhaust fan and motor assemblies are mounted to unit base with 1-inch deflection free standing spring isolators. Fans shall be located in draw-through position in reference to the Energy Recovery wheel.
  - Supply and exhaust fans shall be belt-driven and be adjustable for field balancing. Direct drive fans are not acceptable unless provided with factory mounted, wired and programmed VFDs for field system balancing.
- 3.3.8 Motors and Drives: Motors shall be energy efficient, complying with EPACT standards, for single speed ODP and TE enclosures. Motors shall be permanently lubricated, heavy-duty type, matched to the fan load and furnished at the specified voltage, phase and enclosure. Belt drive motors shall be factory mounted to an adjustable motor plate having two heavy-duty adjusting bolts for alignment and belt tension. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast type, keyed and securely attached to the fan wheel and motor shafts; 10hp and less shall be supplied with an adjustable drive pulley. Energy wheel motors and direct drive motors shall have integral overload protection. Refer to Section 250100 for other requirements.
- 3.3.9 Filters: Supply and exhaust air filters shall be 2-inch-thick pleated fiberglass, MERV 8, 30% efficient and tested to meet UL Class 2. Filter racks shall be die-formed galvanized steel. Both airstreams must be filtered upstream of energy wheel.
- 3.3.10 Electrical: All internal electrical components shall be factory wired for single point power connection. Units with electric post-wheel heat will be wired with independent power supply. All electrical components shall be UL Listed, Approved or Classified where applicable and wired in compliance with UL1995.
- Weatherproof, integral door interlocking disconnect switch, motor starters, control circuit fusing, control transformer for 24 VAC circuit, and terminal strip shall be supplied as standard components in the control center. Motor starters shall be provided for all fan motors and consist of a contactor with a Class 20 adjustable electronic overload protection.
- 3.3.11 Roof Curb: An insulated roof curb to be supplied by unit manufacturer for field assembly. Curb shall consist of die formed galvanized steel sections. Curb shall be full perimeter type with gasketing provided for field installation between curb and unit base. Curb capable of accepting field installed isolation (by others). Slope shall be as required to match roof surface. Curb height is as required to leave 12" of curb exposed *above* the finished roof surface.
- 3.3.12 Electric heat shall be ETL listed and fused per NEC over 48 amps. Electric post heater includes separate non-fused disconnect for field wiring. SCR controls operate to maintain discharge temperature. Electric heater shall be included air flow switch to shut down heater if air ceases to flow across heater.

- 3.3.13 Unit shall be equipped with a pre-piped and wired air-cooled condensing unit. There shall be no field piping required. System shall be equipped with a liquid-line filter drier, high-pressure manual reset cutout, low-pressure auto-reset cutout, time delay relays for compressor protection, service/charging valves, on-off 3-way valve for hot-gas reheat, and moisture indicating sight glass in addition to items specified below:
- 3.3.14 Evaporator coils shall have copper tubes with permanently expanded aluminum fins, 12 fpi or less. Coils shall be tested in accordance with ARI 410. Evaporator coils shall be placed on stainless steel drain pans with external drain connections.
- 3.3.15 Compressors shall be hermetic scroll type, mounted on neoprene vibration isolation to minimize vibration transmission and noise. Compressors shall be mounted in an isolated compartment to be serviceable without affecting airflow. Compressors shall be equipped with a crankcase heater. Units shall have a minimum two (2) stages of capacity control in a dual refrigerant circuit.
- 3.3.16 The system shall come equipped with two thermal expansion valves to control refrigerant flow.
- 3.3.17 Condensing fans shall be direct drive, statically and dynamically balanced, and AMCA Licensed for Air Performance. Multiple condensing fans shall be supplied to allow fan cycling for head pressure control.
- 3.3.18 Condensing coils shall be included as part of integral refrigeration system.
- 3.3.19 Integral DX cooling shall include single row hot-gas reheat coil for neutral air discharge. Coil shall be rated in accordance with ARI 410.
- 3.3.20 The cooling section shall utilize R410a refrigerant.
- 3.4 Controls:
- 3.4.1 Energy recovery ventilator shall include DDC controller and all sensors required for discharge air temperature and dew point control. DDC controller shall include internal time clock to energize unit when occupied or can be controlled from a signal from others. Controller shall have LCD readout for changing set points and monitoring unit operation at the control center.
- 3.4.2 DDC controller shall interface with BMS system through Lon works FFT-10A, Modbus-RTU (over RS-485), BACnet IP, BACnet MS/TP. When in economizer mode, energy wheel shall stop rotating to allow free cooling based on outdoor air temperature, enthalpy.
- 3.4.3 A timed exhaust sequence shall be preprogrammed to defrost energy wheel. Outdoor air temperature sensor and pressure switch across energy wheel shall be provided by unit manufacturer to engage frost control. Both sensors are to be satisfied to employ frost control. Frost control strategies employed via outdoor air temperature sensor only are not acceptable.

3.4.4 Pressure sensors shall be provided on both return air and outdoor air [pre-filters, final filters, both pre-filters and final filters.

3.4.5 Rotation sensor shall be included to monitor wheel rotation.

3.4.6 Factory mounted and wired current sensor shall be provided to signal an increase in current draw above set point is detected in exhaust fan circuit.

3.4.7 Factory mounted and wired current sensor shall be provided to signal an increase in current draw above set point is detected in supply fan circuit.

### 3.5 START UP

3.5.1 Provide services of a factory-trained representative to start-up equipment. Contractor shall assist and cooperate with factory representative as required. Coordinate start-up with TAB and bas contractors. Start-up equipment in accordance with manufacturer's instructions. Refer to Section 200100, "General Provisions-Mechanical" for additional start-up procedures.

- Ensure filters are installed prior to initial start-up; do not start-up or operate equipment without filters in place. Filters shall remain in place through the duration of construction.
- Provide and install new filters upon turn over to Owner.

3.5.2 Test controls and demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.

### 3.6 TRAINING

3.6.1 Provide services of manufacturer's service representative to instruct owner's personnel in operation and maintenance of rooftop air handling units. Training to include start-up and shut-down, servicing and preventative maintenance schedules and procedures, and troubleshooting procedures, and procedures for obtaining replacement parts and technical assistance. Review operating and maintenance data contained in the operating and maintenance manuals specified in Division One. Allow up to 4 hours of training with owner; schedule at least 7 days prior notice.

## **PART 4 - AIR FLOW DAMPERS:**

4.1 ACCEPTABLE MANUFACTURERS: Greenheck or approved equal.

4.2 LEAKAGE: Dampers shall have a maximum leakage of 6 cfm/ sq. ft. @ 4 in. wg or 3 cfm/ sq. ft. @ 1 in. wg. Damper shall meet or exceed the IECC (International Energy Conservation Code) requirements for damper leakage ratings of 3 cfm per sq. ft. @ 1 in. wg or 8 cfm per sq. ft @ 4 in. wg or less when integral to the building envelope.

4.3 DIFFERENTIAL PRESSURE: Dampers shall have a maximum differential pressure rating of 4 in. wg. (1kPa)

- 4.4 VELOCITY: Dampers shall have a maximum velocity rating of 3000 fpm (15.2 m/s).
- 4.5 FRAME: On AMD-42 damper frame shall be galvanized steel formed into a 5" x 1" structural hat channel with a 16 ga. thickness.
- 4.6 BLADES: Damper blades shall be a fabricated airfoil shape with metal blade to blade overlay. Each blade shall be symmetrical relative to its axle pivot point, presenting identical performance characteristics with air flowing in either direction through the damper. Blade orientation is horizontal, and operation is parallel.
- 4.7 BLADE STOPS: Each blade stop (at top and bottom of damper frame) shall occupy no more than ½" of the damper opening area to allow for maximum free area and to minimize pressure loss across the damper.
- 4.8 SEALS: Blade Edge: TPE blade seals come standard which are mechanically fastened to each blade. Jamb: 304 stainless steel.
- 4.9 LINKAGE: Concealed in frame out of the airstream, plated steel material.
- 4.10 AXLES: Minimum ½ inch dia. plated steel. Stainless steel axle is optional. Removable control shaft extends 6" beyond the damper frame.
- 4.11 BEARINGS: Synthetic bearings are provided standard.
- 4.12 SLEEVE: 12 inch 20 gauge sleeve provided standard with air straightener mounted in the sleeve.
- 4.13 CONTROLLER: Lon based programmable controller provides
- 0-10 VDC feedback for airflow, temperature, and positions of the blade
  - 0-10 VDC for setpoints
  - 2-10 VDC or 4-20 mAdc is available as an option.
- 4.14 Air straightener contained in sleeve attached to the damper frame.
- 4.15 FINISH: Mill Galvanized finish is standard.
- 4.16 TEMPERATURE RATING: -20° F to 180° F (-29° C to 82° C).
- 4.17 MOUNTING: The AMD-42 is suitable for horizontal airflow applications.
- 4.18 ACTUATORS: Type: Electric, 24V AC, modulating, fail close; Mounting: External
- 4.19 FLANGES: 1-1/2 inches, rolled formed as part of the sleeve.
- 4.20 Examine areas to receive dampers. Notify the Engineer of conditions that would adversely affect installation or subsequent utilization of dampers. Do not proceed with installation until unsatisfactory conditions are corrected.
- 4.21 Install dampers in accordance with manufacturer's Installation Instructions.

- 4.22 Dampers must be accessible to allow inspection, adjustment, and replacement of components. The sheet metal contractor shall furnish any access doors in ductwork or plenums required to provide this access. The general contractor shall furnish any access doors required in walls, ceilings, or other general building construction.
- 4.23 Install dampers square and free from racking.
- 4.24 The installing contractor shall provide and install bracing for multiple section assemblies to support assembly weight and to hold against system pressure.
- 4.25 Do not compress or stretch the damper frame into the duct or opening.
- 4.26 Attach multiple damper section assemblies together in accordance with manufacturer's instructions. Install support mullions as reinforcement between assemblies as required.
- 4.27 Handle dampers using the frame or sleeve. Do not lift or move dampers using blades, actuator or jackshaft.
- 4.28 Install connections to electric actuators as specified in section CONTROLS.

**END OF SECTION**

**SECTION 23 08 00**

**HVAC COMMISSIONING**

**PART 1 – GENERAL:**

1.1 RELATED WORK

1.1.1 Division 22 – Plumbing

1.1.2 Division 26 – Electrical

1.2 REFERENCES

1.2.1 Drawings and general provisions of contract, including general and supplementary conditions, general mechanical provisions and Division-1 Specification sections, apply to work of this section.

1.2.2 ASHRAE Guideline 1-1996

1.2.3 ASHRAE Guideline 0-2005

1.2.4 ACG Commissioning Guideline – 2005

1.3 DESCRIPTION OF WORK

1.3.1 The purpose of the commissioning process is to provide the owner/operator of the facility with a high level of assurance that the mechanical systems have been installed in the prescribed manner, and operate within the performance guidelines set in the Basis of Design Documents (BOD). The CA shall provide the owner with an unbiased, objective view of the system's installation, operation, and performance. This process is not intended to take away or reduce the responsibility of the design team or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems for beneficial use by the owner. The CA will be a member of the construction team, administering and coordinating commissioning activities with the design team, construction manager, subcontractors, manufacturers and equipment suppliers.

1.3.2 The independent commissioning agent (CA) contracted directly with the owner for this project. This specification has been included for reference only to define contractors' responsibilities. Each contractor should review this procedure and include adequate time in their proposal.

**PART 2 – PRODUCTS:**

Not used.

**PART 3 – EXECUTION:**

3.1 ROLES OF THE COMMISSIONING AGENCY

- 3.1.1 The primary point of responsibility is to inform the construction manager, the owner and design team on the status, integration, and performance of HVAC systems within the facility.
- 3.1.2 The CA shall function as a catalyst and initiator to disseminate information and assist the design and construction teams in implementing completion of the construction process. This shall include system verification, functional performance testing, and conformance with the intended design of each system. Services include documenting construction observations, verification and functional performance testing, and documenting proper distribution of performance and operating information to the owner's O&M staff.
- 3.1.3 Assist the responsible parties to maintain a high quality level of installation by meeting or exceeding prevailing standards and specifications.
- 3.1.4 The CA shall observe and coordinate testing as required to assure system performance meets the design intent.
- 3.1.5 The CA shall document the results of the performance testing directly and/or assure that the appropriate technicians document testing. The CA shall approve standard forms to be used by all parties for consistency of approach and type of information to be recorded.
- 3.1.6 The CA shall provide technical expertise to oversee and verify the correction of deficiencies found during the commissioning process.
- 3.1.7 The CA is to remain an independent party with specific knowledge of the project. The CA shall investigate the scope and extent of the problem and facilitate communication to determine responsibilities by delineating specifications. The CA shall monitor resolution for conformance with design intent and prevailing industry standards.
- 3.1.8 The CA shall document the date of acceptance as determined by the construction manager, owner and design team. System Verification Checklists and Functional Performance Test results may be used in determining the start of the warranty period for HVAC systems and subsystems.
- 3.1.9 The CA will review operating and maintenance materials for HVAC systems.
- 3.1.10 The CA will review phasing plans as provided by the CM relating to temporary use of HVAC equipment, O&M considerations, warranty issues, impact of construction sequencing on occupied areas, and interruption of services from the existing equipment.

### 3.2 SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS

- Pumps
- Heat Pumps
- OA units
- Exhaust Fans
- DDC Control System
- AC Units

### 3.3 HVAC COMMISSIONING PLAN

- 3.3.1 Commissioning Team: The Commissioning Team (CT) shall consist of key parties involved in design, construction and testing of this facility. It is necessary for each agency to appoint team members that will have long-term commitments to this project. Switching team members during the project will reduce the ability of the CT to provide continuity and acceptable results to the building owner. Team members must maintain an ongoing supervisory position on this project. One team member shall be provided by each of the parties listed below:

Program Manager (PrM)  
Facilities Management Division (FMD)  
Commissioning Agent (CA)  
Design Team (DT)  
General Contractor (GC)  
Mechanical Contractor (MC)  
Controls Contractor (CC)  
Test and Balance Contractor (TABC)  
Electrical Contractor (EC)

#### 3.3.2 Basis of Design Document

- The Basis of Design Document (BOD) represents a composite of design drawings, project specifications, submittals, change orders and industry standards that describe the systems of this facility. References to design intent will be taken from these contract documents. The BOD is an evolving manuscript maintained by the design professional to track and incorporate design alterations that occur throughout the construction process. Any industry standards used for this project will be specifically noted when referenced.
- The CA will review the BOD documents for adequate commissioning provisions, functional performance, optimization of performance, accessibility, TAB provisions, and O&M considerations.

- 3.3.3 Commissioning Meetings: Commissioning meetings will be held in conjunction with progress meetings as necessary. The CA will be on site for the CX meetings. Commissioning meetings will be used to address any problems that alter the design intent or affect the commissioning process. These meetings provide an open forum for exchange of ideas between contractors, vendors, designers, users and owners.

#### 3.3.4 Resolution Tracking Forms (RTF)

- The use of Resolution Tracking Forms is a method employed by the CA to monitor and record problems, their causes, and solutions. The use of these lists promotes communication between the installing contractors, design team, commissioning agent, and owner, in order to expedite their resolution in a timely manner.
- The CA will regularly submit RTF's to the CT in order to document and resolve deficiencies as quickly as possible. The frequency of RTF submission will be adjusted as project conditions dictate.

#### 3.3.5 System Verification Checklists (SVC) / Manufacturers' Checklists

- The MC will provide SVC's based on manufacturers start-up procedures. These tests should be provided for all systems and subsystems. See *SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS*. Draft copies will be submitted to the CT for review and comment prior to placement on the job site. A master copy of the SVC's will be bound in a three-ring binder and placed on the job site for use by the installing contractors. No system will be started until the appropriate SVC's have been completed.
- The CA will review the SVC for each piece of equipment prior to start-up. Equipment will be released for start-up only after these checklists have been completed by the installing contractor and reviewed by the CA.
- The equipment manufacturers' checklists must also be reviewed by the CA prior to start-up. These lists must be completed by the installing contractor, and reviewed by the CA before start-up can commence.

### 3.3.6 Start-Up

- Start-up of major HVAC systems will be witnessed the CA. The appropriate contractors and/or manufacturer's representative will be required on site to perform start-up. No system will be started until the appropriate SVC's have been completed. No system will be started until the Manufacturer's checklists have been completed. Start-up will be performed according to the Manufacturer's recommended procedures. The CA will visit the site to review completeness of installation in conjunction with progress meetings prior to starting HVAC equipment.
- CT members involved in installation, fabrication, manufacture, control, or design of equipment are required to be present at the time of start-up. A factory-authorized technician will be on site to start equipment when required by the specifications. This will minimize delays in bringing equipment on line and expedite acceptable functional performance in accordance with the BoD.

3.3.7 Controls Monitoring: Close monitoring of the Control Contractor's progress will promote efficient coordination of the TAB work. The CC will be expected to submit point-to-point checklists verifying that his work has been completed and all systems are ready for TAB work and Functional Performance Testing. Programming and graphics will be surveyed by the CA for completeness and conformance with the BoD and the owner's scheduling requirements.

### 3.3.8 TAB Monitoring

- The preliminary TAB report set-up will be reviewed prior to HVAC equipment start-up, in order to assure that the final TAB report format and content is acceptable.
- TAB work will be monitored so that any problems that prevent or hinder proper air and water balance can be addressed and corrected with minimal delays. By addressing these problems as quickly as possible, we can assure that functional performance testing and owner training will take place on schedule.
- A pencil copy of the TAB report will be reviewed prior to submission of the final TAB report. A written review will be submitted to the TAB contractor and to the DT for their comments. A TAB report approved by the DT will be required before Functional Performance Testing can be carried out. The CA will visit the site during the TAB process in order to assist TABC and CC in the effective completion of their scope of work.

### 3.3.9 Functional Performance Tests (FPT)

- The CA will write FPT's based on the respective sequence of operations. These tests will be created for systems and subsystems. See *SYSTEMS INCLUDED IN THE COMMISSIONING PROCESS* above.
- Each major system will be tested. A random sample of each subsystem will be tested. This will be coordinated and witnessed by the CA and the owner's maintenance staff. Witnessing the FPT's will serve as a compliment to the O&M Training. No FPT's will be performed until the system and related subsystems have been started, the TAB report has been submitted and reviewed, and the completion of the control system has been documented through point-to-point checklists and other documentation.
- The Functional Performance Tests shall include HVAC and related equipment.
  - Units will be tested in designed operating modes. Proper operation will be verified at automatic control, and other modes, if necessary, to achieve BOD conformance.
  - DDC control systems will be tested as necessary.
  - HVAC systems will be tested to assure that the building as an integrated system operates properly.
  - Trend verification of systems and subsystems shall be completed prior to start of functional performance testing. CA will provide trend format to CC and discuss trend requirements in CX meetings throughout the construction phase of project.
- Deferred Testing
  - If tests cannot be completed because of a deficiency outside the scope of the responsible contractor, the deficiencies shall be documented and reported to the Owner. Deficiencies shall be resolved and corrected by the appropriate parties and test rescheduled.
  - Off-season mode testing will be implemented as necessary to assure conformance with the BoD. Installing contractors will be expected to participate as required by the project specifications.
- Rescheduled Functional Performance Test
  - During Functional Performance Testing period, it is assumed that the contractors will be complete with all checklists when the commissioning agents travel to site. If the work is not ready for commissioning when the commissioning personnel are on site, their time will be billed to the contractor as an additional fee.
  - If the contractor has deficiencies that cannot be corrected at the time of the test, that part of the sequence will be retested at a later date. If the deficiency does not pass during the retest, the contractor will be billed for the commissioning personnel's return trip.
- Building Turn-Over / Owner Orientation / User Training
  - The CA will oversee contractors prepare, coordinate and review O&M manuals, working closely with each contractor to achieve specificity and completeness.
  - The CA will review as-built drawings, working closely with each contractor to achieve specificity and completeness.
  - Owner training will be coordinated with the assistance of the CA. The training will be provided by the installing contractor, or manufacturer's representative, and witnessed by the CA. This training should include both classroom training and hands-on operational training. The owner may choose to videotape this training for future use. The CA will visit the site during the Turn-Over and Training period

to assure that any on-going HVAC related problems are being addressed and corrected in a timely and efficient manner.

- The CA will assist in the coordination of off-season testing, calibrating, and servicing as specified in the contract documents.

### 3.4 RESPONSIBILITIES OF TEAM MEMBERS

#### 3.4.1 General Contractor (GC)

- Include commissioning requirements in the mechanical, electrical, and controls contracts, as well as other subcontracts, to assure full cooperation of all parties in the HVAC commissioning process.
- Assure acceptable representation, with the means and authority to prepare and coordinate execution of the mechanical commissioning program as described in the contract documents.
- Assure that the CA shall receive a copy of all construction documents, addenda, change orders and appropriate approved submittals and shop drawings for review and use in development of the commissioning plan.
- Coordinate inclusion of commissioning activities in the construction schedule.
- Facilitate resolution of deficiencies identified by observation or performance testing.
- Assist the CA in monitoring the duct leakage testing.

#### 3.4.2 Mechanical Contractor (MC)

- Each contractor in this division shall include in their quote the cost of participating in the commissioning process.
- Include requirements for submittal data (including partial load data), O&M data, and training in each purchase order or sub-contract.
- Assure cooperation and participation of specialty sub-contractors such as sheet metal, piping, refrigeration, water treatment, temperature controls, and TAB in commissioning activities.
- Assure participation of major equipment manufacturers in appropriate startup, training, and testing activities.
- Attend commissioning meetings scheduled by the CA.
- Assist the CA in system verification and performance testing.
- Prepare preliminary schedule for HVAC system inspections, O & M manual submission, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, system verification, performance testing, and system completion for use by the CA. Update schedule as appropriate throughout the construction period.
- Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of HVAC equipment.
- Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- Notify the CA a minimum of two weeks in advance of scheduled system start-up.
- Update drawings to as-built condition and review with the CA throughout the construction process.
- Schedule vendor and subcontractor provided training sessions as required by project specifications.

- Provide written notification that the following work has been completed in accordance with the project specifications, and that the equipment, systems and sub-systems are operating in accordance with design intent.
  - HVAC equipment including fans, HP units, ductwork, dampers, terminal devices, etc.
  - Fire detection and smoke detection devices furnished under other divisions as they affect the operation of the HVAC systems.
  - That BAS is functioning in accordance with design intent.
- Participate in the Functional Performance Tests.
- Participate in the off-season mode testing.
- Participate in O&M Training as required by project specifications.
- Provide a complete set of as-built drawings and O & M manuals for review. The CA shall review the as-built drawings and O&M manuals concurrently with the design team.

#### 3.4.3 Test and Balance Contractor (TABC)

- Include cost for commissioning requirements (participation) in the contract price.
- Attend commissioning meetings scheduled by the CA.
- Submit the TAB procedures and preliminary TAB report to the CA for review at least two weeks prior to beginning TAB work.
- Notify the CA a minimum of two weeks in advance of scheduled TAB work.
- Provide partial, preliminary TAB Reports by phase, by building section, by system, or as required by the CA.
- Assist the CA in system verification and performance testing.
- Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- Participate in verification of the TAB report, which will consist of repeating any selected measurement contained in the TAB report where required by the CA for verification or diagnostic purposes.
- Participate in the Functional Performance Tests as required to achieve design intent.
- Provide sound and vibration where required to assist in diagnosis of areas exhibiting unacceptable levels of noise or vibration.
- Participate in the off-season mode testing as required to achieve design intent.
- Participate in O&M Training as required by project specifications.

#### 3.4.4 Temperature Control Contractor (TCC)

- Include cost for commissioning requirements in the contract price.
- Review control sequence and component selection for conformance with design intent.
  - Attend a submittal review meeting with the CA and Engineer to ensure clear understanding of scope of work and expectations.
  - Verify that specified safeties and interlocks have been selected.
  - Verify proper selection of control valves and actuators based on design parameters.
  - Verify proper selection of control dampers and actuators based on design parameters.
  - Verify that sensor selection conforms to design intent.
- Attend commissioning meetings scheduled by the CA.

- Provide the following submittals to the CA:
  - Hardware and software submittals.
  - Control panel construction shop drawings.
  - Narrative description of control sequences for each HVAC system and subsystem.
  - Schematics showing all control points, sensor locations, point names, actuators, controllers and where necessary, points of access.
  - A list of all control points, including analog inputs, analog outputs, digital inputs and digital outputs. Include the values of all parameters for each system point. Provide a separate list for each stand-alone control unit.
  - A complete listing of all software routines employed in operating the control system. Also provide a program narrative that describes the logic flow of the software and the functions of each routine and sub-routine. The narrative should also explain individual math or logic operations that are not clear from reading the software listing.
  - Hardware operation and maintenance manuals.
  - Application software and project applications code manuals.
  - Panel and equipment insert documents.
  - Assist CA with remote monitoring capabilities. Supply any software and/or hardware needed.
- Verify that specified interfaces provided by others are compatible with BAS hardware and software.
- Coordinate installation and programming of BAS with construction and commissioning schedules.
- Complete System Verification Checklists and manufacturer's pre-start checklists prior to scheduling startup of HVAC equipment.
- Provide control system technician to assist during equipment startup.
- Monitor and respond to Resolution Tracking Forms distributed by the CA in order to expedite corrective actions necessary to achieve design intent.
- Participate in the Functional Performance Tests as required by the project specifications.
- Provide a control system technician to assist during verification and performance testing.
- Provide system modifications to achieve system operation as defined by the design intent.
- Provide support and coordination for TAB contractor. Provide all devices, such as portable operator terminals and all software for the TAB to use in completing TAB procedures.
- Provide written notification that the TCC scope of work has been completed in accordance with the project specifications, and that the equipment, systems and sub-systems are operating in accordance with design intent, and that BAS is functioning in accordance with design intent.
- Participate in the Functional Performance Tests as required to achieve design intent.
- Participate in the off-season mode testing as required to achieve design intent.
- Participate in O&M Training as required by project specifications. Include training on hardware operations and programming

**END OF SECTION**

## **SECTION 23 11 00**

### **REGISTERS, GRILLES, DIFFUSERS & LOUVERS**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.

#### **PART 2 – REGISTERS, GRILLES AND DIFFUSERS:**

- 2.1 Acceptable R, G & D manufacturers are Price, Metalaire, and Titus. Shop drawings shall identify and list all characteristics of each device exactly as scheduled herein. Finishes for specified devices shall be selected by the Architect. Factory color samples shall be submitted with shop drawings. Devices shall be white unless noted otherwise. Aluminized steel devices are not acceptable. Steel devices are not acceptable unless specifically noted otherwise.
- 2.2 Include with the shop drawings a room-by-room schedule indicating devices installed. Also note ceiling types and installations.
- 2.3 Refer to drawings for schedule.

#### **PART 3 – LOUVERS:**

- 3.1 Acceptable louver manufacturers are Ruskin, United Enertech, Arrow. Shop drawings shall identify and list all characteristics of each device exactly as scheduled herein. Finishes shall be selected by the Architect. Factory color samples shall be submitted with shop drawings.
- 3.2 Refer to drawings for schedule.

**END OF SECTION**

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## **SECTION 23 12 00**

### **SHEET METAL**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 This branch of the work includes all materials, labor and accessories for the fabrication and installation of all sheet metal work as shown on the drawings and/or as specified herein. Where construction methods for various items are not indicated on the drawings or specified herein, all such work shall be fabricated and installed in accordance with the recommended methods outlined in the latest edition of SMACNA's Duct Manual and Sheet Metal Construction for Low Velocity Ventilating and Air Conditioning Systems. All equipment furnished by manufacturers shall be installed in strict accord with their recommended methods.
- 1.3 Ductwork shall be constructed and installed per the latest edition of the International Mechanical Code.
- 1.4 Ductwork shall be kept clean at all times. Ductwork stored on the job site shall be placed a minimum of 4" above the floor and shall be completely covered in plastic. Installed ductwork shall be protected with plastic. Do not install the ductwork if the building is not "dried-in". If this is required, the entire lengths of duct shall be covered in plastic to protect. The Owner/Engineer shall periodically inspect that these procedures are followed. If deemed unacceptable, the Contractor shall be required to clean the duct system utilizing a NADCA certified Contractor.
- 1.5 Prior to purchase and fabrication of ductwork (shop fabricated or manufactured), the Contractor shall coordinate installations with new and existing conditions. Notify the Engineer if there are any discrepancies for resolution.
- 1.6 For healthcare projects, provide a SMACNA duct cleanliness level "C" per the latest SMACNA standards.

#### **PART 2 – LOW VELOCITY DUCTWORK:**

- 2.1 Ductwork, plenums and other appurtenances shall be constructed of one of the following: Steel sheets, zinc coated, Federal Specification 00-S-775, Type I, Class E & ASTM A93-59T with G-90 zinc coating. Aluminum alloy sheets 3003, Federal Specification AA-A-359, Temper H-14. Utilize Aluminum in MRI Scan Rooms.
- 2.2 Ductwork, plenums and other appurtenances shall be constructed of the materials of the minimum weights or gauges as required by the latest SMACNA 2" W.G. Standard or

below table. When gauge thickness differs, the heavier gauge shall be selected. The below table shall serve as a minimum.

<u>Round Diameter Gauge</u>	<u>Duct Gauge</u>	<u>Rectangular Width</u>	<u>Duct</u>
3-12 Inches	26 Ga.	3-12 inches	26 Ga.
12-18 Inches	24 Ga.	13-30 inches	24 Ga.
19-28 Inches	22 Ga.	31-54 inches	22 Ga.
29-36 Inches	20 Ga.	55-84 inches	20 Ga.
37-52 Inches	18 Ga.	85 inches and up	18 Ga.

- 2.3 All ductwork connections, fittings, joints, etc., including longitudinal and transverse joints, seams and connections shall be sealed. Seal with high velocity, smooth-textured, water-based duct sealant. Sealant shall be UL 181B-M listed, UL 723 classified, NFPA 90A & 90B compliant, permanently flexible, non-flammable, and rated to 15"wg. Apply per manufacturer's recommendations. Contractors shall insure no exposed sharp edges or burrs on ductwork.
- 2.4 Duct dimensions indicated are required inside clear dimensions. Plan duct layouts for adequate insulation and fitting clearance.
- 2.5 All angular turns shall be made with the radius of the center line of the duct equivalent to 1.5 times the width of the duct.
- 2.6 Cross-break all ducts where either cross sectional dimension is 18" or larger.
- 2.7 Ducts shall be hung by angles, rods, 18 ga. minimum straps, trapezes, etc., in accordance with SMACNA's recommended practices. Duct supports shall not exceed 12 ft intervals. There shall be no less than one set of hangers for each section of ductwork. Where ductwork contains filter sections, coils, fans or other equipment or items, such equipment or items shall be hung independently of ductwork with rods or angles. Do not suspend ducts from purlins or other weak structural members where no additional weight may be applied. If in doubt, consult the Structural Engineer.
- 2.8 Double turning vanes shall be installed in square turns and/or where indicated.
- 2.9 Provide a "high efficiency" type take-off with round damper (Flexmaster STOD-B03 or approved equal) for all round duct branches from a rectangular main to a GRD. Refer to the detail on the drawings for all installation requirements.
- 2.10 Air volume dampers shall be installed in each duct branch takeoffs and/or where indicated, whichever is more stringent. All such dampers shall be accessible without damage to finishes or insulation and shall be provided where required for proper system balance.
- 2.11 Unless otherwise dimensioned on the drawings, all diffusers, registers and grilles shall be located aesthetically and symmetrically with respect to lighting, ceiling patterns, doors, masonry bond, etc. Locate all supply, return and exhaust diffusers and grilles in the locations shown on the architectural reflected ceiling plan.

- 2.12 The interior surface of the ductwork connecting to return/exhaust air grilles shall be painted flat black. The ductwork shall be painted a minimum of 24" starting from the grille.
- 2.13 Provide approved flexible connectors at inlet and outlet of each item of heating and cooling equipment whether indicated or not. Install so as to facilitate removal of equipment as well as for vibration and noise control.
- 2.14 All fans and other vibrating equipment shall be suspended by independent vibration isolators.
- 2.15 Miscellaneous accessories such as test openings with covers, latches, hardware, locking devices, etc., shall be installed as recommended by SMACNA and/or as indicated. Test openings shall be placed at the inlet and discharge of all centrifugal fans, VAV boxes, fan sections of air handling units, at the end and middle of all main trunk ducts and where indicated. All such openings shall be readily accessible without damage to finishes.
- 2.16 Whether indicated or not, provide code approved, full sized fire dampers at all locations where ductwork penetrates fire rated walls. Fire stop rating shall meet or exceed the rating of the wall. Provide an approved access panel at each fire damper located and sized so as to allow hand reset of each fire dampers. All such fire dampers and access panels shall be readily accessible without damage to finishes. Refer to Architectural Plans for locations of fire rated walls. All access doors shall be 16"x16" or as high as ductwork permits and 16" in length.
- 2.17 The Contractor who installs the sheet metal shall furnish to the Air Balancing Contractor, a qualified person to assist in testing and balancing the system.
- 2.18 INSULATED FLEXIBLE AIR DUCT: Thermaflex G-KM or equal. Flexible air duct shall be two (2) inch thick fiberglass insulation with CPE liner permanently bonded to a coated spring steel wire helix supporting a fiberglass scrim and fiberglass insulating blanket. Flexible air duct shall be listed under UL Standard 181 as a Class I flexible air duct complying with NFPA 90A and 90B. Maximum flame spread = 25 and maximum smoke developed = 50. Minimum insulating value is R-6.0. Flexible duct shall be used only for GRD runouts and no section shall be more than five feet in length.
- 2.19 FLEXIBLE CONNECTORS: Duro-Dyne, Ventfabrics, Inc., U.S. Rubber or equivalent; conforming to NFPA No. 90A; neoprene coated glass fabric; 20 oz. for low velocity ducts secured with snap lock.
- 2.20 TURNING VANES: Fabricated as recommended by SMACNA: noiseless when in place without mounting projections in ducts. All turning vanes shall be double blade type.
- 2.21 ACCESS DOORS IN DUCTWORK: Flexmaster TBSM, Air Balance, Vent Products or equal. Access doors for rectangular ducts shall be 16"x16" where possible. Otherwise install as large an access door as height permits by 16" in length. Door shall be 2" thick double-wall insulated with continuous hinge and cam lock. Provide in ducts where indicated or where required for servicing equipment whether indicated or not. Provide a hinged access door in duct adjacent to all fire, smoke and control dampers for the

purpose of determining position. Access doors shall also be provided on each side of duct coils and downstream side of VAV boxes and CAV boxes.

- 2.22 ARCHITECTURAL ACCESS DOORS IN CEILINGS OR WALLS: Provide Kees D Panel, Cesco, Milcor or equal. Panels shall be 24"x24" in size and constructed with 16 gauge galvanized steel for door and frame. Provide with primer finish to accept specified finish. Door shall include three (3) screwdriver operated cam latches and concealed continuous pivoting rod hinge. Door shall open 175 degrees. For masonry construction, furnish frames with adjustable metal masonry anchors. For fire rated units, provide manufacturer's standard insulated flush panel/doors with continuous piano hinge and self-closing mechanism. The Contractor shall include all required access doors in the bid and shall coordinate with the General Contractor prior to the bid to insure a complete project.
- 2.23 VOLUME DAMPERS (RECTANGULAR): Ruskin MD35 or Air Balance, Pottorff, rectangular volume dampers. Frames shall be 16-gauge galvanized steel. Blades shall be opposed blade 16-gauge galvanized steel with triple crimped blades on 6" centers. Linkage shall be concealed in jamb. Bearings shall be 1/2" nylon. Maximum single section size shall be 48" wide and 72" high. Provide with Ventfabrics 2" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.
- 2.24 VOLUME DAMPERS (ROUND): Ruskin MDRS25 or Air Balance, Pottorff round volume dampers. Dampers shall be butterfly type consisting of circular blade mounted to axle. Frames shall be 20-gauge steel and 6" long. Damper blades shall be 20 gauge crimped galvanized steel. Axle shall be 3/8"x6" square plated steel. Bearing shall be 3/8" nylon. Provide with Ventfabrics 2" high elevated dial regulator to avoid damper handle from conflicting with duct insulation. Provide permanent mark on dial regulator to mark air balance point.
- 2.25 MOTOR DRIVEN FIRE/SMOKE DAMPERS – AIR FOIL BLADE: Fire damper shall be constructed and tested in accordance with UL Safety Standard 555. The damper shall be Ruskin FSD60. Other acceptable manufacturers are Air Balance or Pottorff. The blade shall be airfoil shaped, constructed of a dual skinned galvanized steel, 14 gauge equivalent thickness, on 6" maximum centers. Frame is to be a minimum of 16 gauge galvanized steel, rollformed into a structural hat shape channel. Frame seals shall consist of flexible, compression type stainless steel. The damper and actuator electric shall be rated to an elevated temperature or 250 degrees F or 350 degrees F. In addition the damper must be factory supplied with actuator and sleeve to comply with the requirements of UL 555S. These dampers shall have been constructed and tested in compliance with U.L. Standard 555 and U.L. Standard 555S, current editions. The pressure drop shall not be greater than .25 in.wg. At 2500 fpm when tested by an independent laboratory. Each damper shall bear an approved U.L. label identifying its classification as a Dynamic Rated fire Damper (Static Rated dampers are not acceptable), and shall further be classified by U.L. as a Leakage Rated Damper for use in Smoke Control Systems. Each damper shall have a 1-1/2 hour fire protection rating, 212EF U.L. Listed fusible link and a leakage class I. In addition to the leakage ratings already specified herein, the dampers and their actuators shall be qualified under UL555S to an elevated temperature of 350 degrees F. Appropriate electric actuators shall be installed by the damper manufacturer. Refer to building fire alarm and controls

for exact type. Provide factory supplied caulked sleeve, 20 gauge on dampers through 84" wide and 18 gauge above 84" wide. Actuator to be mounted outside of air stream. Provide factory supplied caulked sleeve, gauge as required to meet manufacturer UL installation requirements.

- 2.26 **PRESSURE RELIEF DOORS:** Provide a pressure relief door in the outside air ductwork at each air handling unit. It shall be located where shown on the drawings. It shall be sized to relieve the duct air pressure below the rated pressure construction of the ductwork and above the working pressure of the fan. The outside air relief door shall be Ruskin PRD18 or equal. Provide a vacuum relief door in the exhaust air ductwork. It shall be located where shown on the drawings. It shall be sized to relieve the duct vacuum below the rated construction of the ductwork and above the working negative pressure of the fan. The return air relief door shall be Ruskin NRD18 or equal. Automatic fan shutdown upon damper closure shall not be an acceptable protection for either overpressure or vacuum conditions. All duct relief dampers shall be of the automatic resetting type.

**PART 3 – EXPOSED OVAL DUCTWORK NOTED ON THE DRAWINGS:**

- 3.1 Prior to purchase/shipment of the ductwork, manufacturer shall provide as part of the submittal process scaled, field coordinated Autocad drawings of the complete system to be furnished. Drawings will indicate all system components including fittings, ductwork and manifolds. Drawings shall be available in an electronic format.
- 3.2 Furnish and install where indicated double wall duct. The double wall duct shall be Eastern Sheet Metal, United McGill, Semco or approved equivalent. The duct shall have an inner shell, a 1-inch layer of fiberglass insulation and an outer pressure shell.
- 3.3 Ductwork outer shell shall be spiral, lock-seam construction fabricated from galvanized steel meeting ASTM-527 standard. Any ductwork exposed to view shall be constructed of G90 galvanized steel, 20 gauge, and shall be supported as required with aircraft cables and self-tightening locks. Exposed metal shall be prepped and cleaned prior to painting. Coordinate with General Contractor. Ductwork shall be constructed as specified in LOW VELOCITY DUCTWORK.
- 3.4 Inner shell for spiral pipe shall be 26 gauge solid galvanized steel, as noted on drawings. Ductwork shall have 3 intermediate reinforcing ribs and be constructed of the minimum gauge specified.
- 3.5 Inner shell for fittings shall be galvanized steel. All fittings shall be manufactured by the same manufacturer as the spiral pipe. Fittings shall be constructed a minimum of 22 Ga.
- 3.6 The fiberglass liner shall have a maximum thermal conductivity (k) factor of 0.27 btu per hour per square foot per degree Fahrenheit per inch thickness at 75 degree F ambient temperature.
- 3.7 All double wall ductwork will be furnished with factory installed flanges equal to Eastern Sheet Metal Flange which shall consist of a 1-1/2" outer flange and an inner secondary flange which shall keep the inner flange concentric and eliminate inner wall connections.

Flanges requiring inner couplings will not be allowed, no insulation shall be exposed to the airstream at the connections.

- 3.8 All grille and register taps shall be factory manifolded. Field installed taps will not be allowed. Manifolded taps may be tack welded and caulked for appearance. Only taps for grilles and registers may be provided this way. All other fittings shall be full body welded.

**PART 4 – UNIT BATH WITH SHOWER EXHAUST DUCTWORK (APPLIES TO EXHAUST DUCTWORK TAKE-OFF AND RUN-OUT):**

- 4.1 All exhaust duct shall be 24 gauge aluminum with liquid tight joints. Provide dielectric connection between steel and aluminum ductwork.
- 4.2 All ductwork shall be sloped so as to drain back toward the shower and dressing rooms.
- 4.3 All dampers and hardware shall be aluminum.

**PART 5 – DRYER VENT DUCTWORK**

- 5.1 All dryer ducting shall be a minimum of 4" in diameter. Refer to the drawings for exact duct sizing.
- 5.2 Dryer vent ductwork shall be rigid metal 20-gauge aluminum duct. "Dryer ducts shall have a smooth interior finish and be supported at 4-foot intervals." Duct joints shall be installed so that the male end of the duct points in the direction of the airflow. Joints shall be secured with metal tape (not duct tape). Do not use rivets or screws in the joints or anywhere else in the duct as these will incur lint collection.
- 5.3 Length of concealed rigid metal ducting shall not exceed the allowable length of 35 feet. Deduct 5 feet from the allowable length for every 4" 90 degree elbow and 4" 2.5 feet for every 45 degree fitting. These lengths may vary per local codes and dryer manufacturer's recommendations. Install per 2012 IMC Section 504 Clothes Dryer Exhaust. Provide a complete, working in-line booster fan system, including power, if the maximum allowable duct length is exceeded.
- 5.4 Flexible transition hose connection at the dryer shall be the aluminum flexible duct type. Do not use the plastic or vinyl.
- 5.5 Termination of dryer venting shall be to the exterior with a proper hood or roof jack equipped with a backdraft damper. Hood/jack shall be painted with suitable exterior grade paint and color per the Owner's direction. Small orifice metal screening shall not be part of the hood or roof jack as this will trap lint and block the opening. The hood opening shall point down and maintain a minimum of 12 inches of clearance between the bottom of the hood and the ground or other obstruction.

**PART 6 – AIR LEAKAGE TESTING OF THE DUCTWORK SYSTEMS:**

- 6.1 It is the intent of this section to ensure the outdoor air ductwork installed has minimal air leakage. Air leakage testing shall be accomplished by an AABC or NEBB certified company. Refer to the Test & Balance specifications. Whenever the systems are being leak tested by the Test & Balance Contractor, a representative from the Mechanical Contractor shall be present to assist.
- 6.2 Carefully select the ductwork construction requirements and the type of duct sealant to be used as required to meet the leakage allowances. The sheet metal duct pressure classification is a minimum only. The Contractor shall select the appropriate sheet metal pressure classification, duct sealant class and duct sealant materials to meet the project air leakage allowances.
- 6.3 The entire outdoor air ductwork system associated with OA-1 and OA-2 shall be tested with some exceptions.
- 6.4 Flexible ductwork shall not be tested. Cap the main duct prior to the central equipment fan connection. Also cap the branch ducts which serve the diffusers, after the round branch air volume with sheet metal caps. Seal caps well to damper to avoid air loss at this location. This air loss, from the caps, is included in the noted leakage rate.
- 6.5 A duct pre-installation conference shall be held prior to the installation of the ductwork. Present should be the Owner, Engineer, Test & Balance Contractor, Construction Manager, Mechanical Contractor, Sheet Metal Contractor and Insulation Contractor. At this meeting, the Contractor shall advise all of the duct materials and sealant materials to be used to meet the air leakage allowances.
- 6.6 It is the intent to test all ductwork. The duct systems which will require testing are as follows:
- All outside air duct systems associated with OA-1 and OA-2.
- 6.7 Do not insulate the supply air systems prior to testing.
- 6.8 The maximum allowable supply air leakage rate is 2.5% of the systems design CFM when the ductwork is pressurized to 2.5" WG. Therefore, if a supply air system is tested, and the supply air fan rated capacity is 10,000 CFM, the allowable leakage is 250 CFM. The maximum allowable return air and exhaust air leakage rate is 2.5% of the system design when the ductwork is pressurized to 1.50" WG.
- 6.9 The noted allowable leakage rate is the total allowable. It shall include leakage associated with the following:
- All ductwork as described in above paragraphs.
  - Access doors
  - Volume dampers
  - Relief air doors
  - Combination Fire/Smoker dampers
  - End caps used to seal ducts

- 6.10 If any duct system fails a test, the Contractor shall reseal the system. It shall than be retested until the duct system meets the leakage allowment at no additional cost to the Owner.

**END OF SECTION**

## **SECTION 25 01 00**

### **ELECTRIC MOTORS AND OTHER ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT**

#### **PART 1 – GENERAL:**

- 1.1 The Contractor's attention is directed to the General and Special Conditions, GENERAL PROVISIONS - MECHANICAL and to all other Contract Documents as they apply to this branch of the work. Attention is also directed to all other sections of the Contract Documents which affect the work of this section and which are hereby made a part of the work specified in this section.
- 1.2 Through coordination with other Contractors, Vendors and Suppliers associated with this Project, this Contractor shall insure a complete, 100% functional, tested, inspected and approved systems. Claims for additional cost or change orders will immediately be rejected. Refer to Specification Section – HVAC EQUIPMENT for additional requirements. All equipment shall be furnished for a single point electrical connection unless specifically excluded as a requirement.
- 1.3 Review the Specification Section - CONTROLS to determine controls, including variable frequency drives, to be furnished.
- 1.4 Prior to ordering any materials or rough-in of any kind, the Mechanical Contractor shall be responsible for final coordination of all electrical requirements (i.e. voltage, phase, circuit breaker, wire sizing, etc.) with the Electrical Contractor. There will be no change in the Contract Amount for any discrepancies. A final coordination meeting shall be held with the Architect, Owner, Engineer, General Contractor, Mechanical Contractor, Electrical Contractor and their sub-contractors.

#### **PART 2 – MOTORS:**

- 2.1 The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications and drawing schedules.
- 2.2 Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
- 2.3 Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.
- 2.4 Motors shall be capable of frequency of starts as indicated by automatic control system and not less than five (5) evenly time spaced starts per hour for manually controlled motors.
- 2.5 Motors shall have a 1.15 service factor for poly-phase motors and 1.35 service factor for single phase motors.

- 2.6 Motors shall have a temperature rating for 40 deg C ambient environment with maximum 90 deg C temperature rise for continuous duty at full load with 1.15 service factor and Class B insulation.
- 2.7 Unless otherwise noted or required by application, motors shall conform to NEMA Standard MG 1 (Table 12-10) for general purpose, continuous duty, horizontal, T-frame, single speed, design "A" or "B". Utilize design "C" motors where required for high starting torque.
- 2.8 Motor frames shall be NEMA Standard No. 48 or 56. Use driven equipment (fans, pumps, etc.) manufacturer's standards to suit specific application.
- 2.9 Provide inverter rated motors where variable frequency drives are utilized. Motor shall be premium efficiency type with Class F insulation and shall conform to NEMA MG 1 parts 30 and 31. Inverter duty rated motors shall have a temperature rating for 40 deg C ambient environment with maximum of 105 deg C temperature rise.
- 2.10 Motor bearings shall be ball or roller bearings with inner and outer shaft seals. Bearings shall be re-greaseable, except permanently sealed where motor is normally inaccessible for regular maintenance. Bearings shall be designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.
- 2.11 Motor enclosure type shall be open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation. Enclosures shall be guarded drip-proof type motors where exposed to contact by employees or building occupants. Enclosure shall be weather protected Type I for outdoor use or Type II where not housed.
- 2.12 Provide built-in thermal overload protection and, where required, internal sensing device suitable for signaling and stopping motor at starter.
- 2.13 Provide energy efficient motors with a minimum EPACT efficiency in accordance with NEMA MG 1, Table 12-10 for 1800 rpm, enclosed motors. If efficiency not specified, motors shall have a minimum efficiency as listed below:
- |                |                |               |
|----------------|----------------|---------------|
| 1 hp - 82.5%   | 7.5 hp - 89.5% | 30 hp - 92.4% |
| 1.5 hp - 84.0% | 10 hp - 89.5%  | 40 hp - 93%   |
| 2 hp - 84%     | 15 hp - 91%    | 50 hp - 93%   |
| 3 hp - 87.5%   | 20 hp - 91%    | 60 hp - 93.6% |
| 5 hp - 87.5%   | 25 hp - 92.4%  | 75 hp - 94.1% |
- 2.14 On the motor nameplate, indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

**PART 3 – MOTOR STARTERS:**

- 3.1 Provide motor starters where indicated on the mechanical equipment schedules or elsewhere in the Contract Documents.
- 3.2 Motor starters shall be NEMA style. Their sizing and installation shall be coordinated with the equipment manufacturer's requirements and in accordance with the National Electrical Code.

- 3.3 All starters shall be size 0 minimum. They shall be constructed and tested in accord with latest edition of NEMA standards. All starters shall be across-the-line magnetic type, unless indicated otherwise. On motors of 20 H.P. or greater rating, the supplier shall provide starters capable of limiting inrush currents. These shall be the reduced voltage open-transition type. Do not utilize closed transition starters unless specifically indicated.
- 3.4 Magnetic starters shall be furnished with the following characteristics and accessories as a minimum. See remaining paragraphs of the Part and mechanical schedules for further requirements.
- 3.5 Contacts shall be silver-alloy, double-break type except NEMA size 8 and 9 shall be single-break type. Contacts shall be replaceable without removal of wiring or removal of starter from enclosure. Number of contacts shall be as required for service indicated. Contacts shall be gravity dropout type, positive operation.
- 3.6 Coil voltage shall be 120 volts, A.C., 60 HZ or less, as required to suit control systems available voltages. Coils shall be of molded construction, except for size 8 and 9 which shall be hand wound. Provide coil clearing contact as required.
- 3.7 Provide control transformer of adequate K.V.A. as required on all starters with line-to-line voltages higher than 120 volts A.C. Provide fuse block and slow-blow fuse to protect control transformer per NEMA, N.E.C. and U.L.
- 3.8 Provide hand-off-auto selector switch in face of starter, wired into hand and off switch positions. Auto position (if needed) to be field wired as indicated for automatic control.
- 3.9 Provide NEMA Class 20 resettable overload relays, accurately sized to the motor nameplate rating of the motor served and the temperature differential between motor and controller. Overloads shall be easily replaceable, and resettable without opening enclosure, via a push button or similar means. Class 10 or Class 30 overloads may be used depending on type of motor duty encountered.
- 3.10 Provide at least one N.O. auxiliary contact (field-convertible to N.C. operation) with each starter. All starters shall have space for two additional single-pole contacts.
- 3.11 All starters shall be thru-wiring type.
- 3.12 Provide phase failure sensing relay to open starter coil circuit (on loss of one or more phases) on all three-phase starters controlling motors of 7½ H.P. or larger.

**PART 4 – ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT:**

- 4.1 All mechanical equipment shall be provided for single point electrical connection unless noted otherwise.
- 4.2 The equipment manufacturer shall provide internally mounted fuses with the equipment, as required, to comply with the U.L. listing on the equipment name plate. (i.e., hermetically sealed compressors or equipment with name plate data that recommends

or requires fuse protection.) See also, National Electrical Code, Article 440, Part C, and other applicable sections of the N.E.C.

- 4.3 It shall be the Contractor's responsibility to assure that all mechanical equipment requiring electrical connections be provided with all required proper wiring, electrical protective devices, disconnecting means and electro-mechanical starting units to properly match the mechanical equipment requirement.
- 4.4 Each separate contractor engaged for the project shall coordinate with all other trades to ensure all necessary equipment and labor is included for fully functioning mechanical systems, installed per Code and Project requirements.
- 4.5 Refrigeration condensing units with internal compressors shall be furnished with integral starter.
- 4.6 All interlock or other control wiring, unless specifically noted otherwise, is the responsibility of this Contractor.
- 4.7 All equipment shall be suitably enclosed. All enclosures for equipment shall be rated and approved for the environment in which it operates. (i.e., NEMA 1, NEMA 3R, NEMA 7, NEMA 12, etc.) Verify the requirement with the installation condition if not indicated on the plans.
- 4.8 Observe the following standards for manufacture of equipment and in selection of components: (1) Starters, control devices and assemblies - NEMA (I.E.C. style not acceptable), (2) Enclosures for electrical equipment – NEMA, (3) Enclosed switches – NEMA, (4) All electrical work, generally NFPA 70, (5) All electrical work in industrial occupancies - J.I.C. standards, (6) All electrical components and materials - U.L. listing required.
- 4.9 Where scheduled on the drawings, provide disconnect switches and contactors. Disconnect switches shall be fusible type or circuit breaker type.

**PART 5 – REQUIREMENTS FOR MECHANICAL EQUIPMENT 3/4 H.P. OR LESS:**

- 5.1 This section describes requirements for small mechanical equipment such as (but not limited to) package terminal heating/cooling units, VAV boxes, unit heaters, unit ventilators, exhaust fans, fans, fan coil units, cabinet heaters, DDC temperature control panels, etc.
- 5.2 Small equipment with motor(s) of 3/4 H.P., single phase or less are generally not required to be furnished with starter(s), unless otherwise noted. For such equipment, provide integral contactor or horsepower-rated relay where controlled by thermostat or other type of switch. Contactors or relays shall be as recommended by the manufacturer of the equipment.
- 5.3 Provide transformer within unit as required to provide low voltage A.C. for thermostat control.
- 5.4 Provide internal fusing for unit motor and other loads in fuse block or in-line fuseholder.

- 5.5 Where externally-mounted disconnecting means is required and would be impractical, unsightly or inappropriate in the judgment of the Engineer, disconnects shall be located within the unit. These disconnects may be fusible H.P.-rated snap switches or manual starters with overload elements, as required. Locate this and other electrical equipment within enclosure where easily accessible behind access panel or door on unit, and as acceptable to the electrical inspector or local authority having jurisdiction.

**END OF SECTION**

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## **SECTION 25 04 00**

### **CONTROLS – DIRECT DIGITAL**

#### **PART 1 – GENERAL:**

- 1.1 The bid for Temperature Controls for this project shall include an allowance. Refer to this document for allowance. Schneider Electric (SE) shall fully integrate the new temperature controls system for this project into the existing Schneider SmartStruxure server/front-end system in the Physical Plant. It is the responsibility of the contractor to coordinate with the temperature control contractor schedules and scope of work. The Allowance for Schneider and the Temperature Control Contractor shall be a subcontractor to the mechanical contractor. Refer to Part 2 for scope details for the Allowance.
- 1.2 The temperature controls for this project shall fully integrate and seamlessly interface to the existing the SmartStruxure front end system in the Physical Plant via BACnet IP protocol. Windowing between different computers/systems, or loading separate building energy management system software on the existing Operator Workstations for interface to the existing Building Energy Management system will NOT be permitted or accepted.
- 1.3 All application specific controllers on all network controllers shall be configurable, commissionable and downloadable through the Server or Network Controller IP connection.
- 1.4 All unitary and field controllers shall be commissioned, upload able and downloadable from the university SmartStruxure server. BACnet IP objects descriptions that are a jumble of letter/numbers are not acceptable. The TCC shall provide a list of points, object descriptions and coordinate with Schneider Electric.
- 1.5 All unitary and field controllers shall be commissioned, up-loadable and downloadable from the university host network automation engine. LON/BACnet/MODBUS object descriptions that are a jumble of letter/numbers are not acceptable.
- 1.6 All controllers, control interface hardware, services, installation, warranty, training, etc., shall be included as hereinafter specified. The system shall utilize a network controller and unitary" type controllers. Including such minor details not specifically mentioned or shown, as may be necessary for the complete operation of the system.
- 1.7 A pre-programming meeting shall be held with the TCC, Engineer, Owner and Schneider Electric to discuss program variable names, room name scheme and system structure.
- 1.8 The Temperature Control Contractor (TCC) shall furnish all labor, materials, equipment, and service necessary for a complete and operating Building Automation System (BAS), utilizing Web Based Direct Digital Controls. All labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned shall be included for the complete temperature controls system.

- 1.9 The TCC shall provide all items, articles, materials, devices, operations or methods listed, mentioned or scheduled on the drawings including all labor, materials, equipment and incidentals necessary and required for their completion to provide a complete and operating temperature control system. This will include connecting to any mechanical equipment furnished with a control interface device and contacting the equipment suppliers and/or manufacturers for information for the proper interface to the equipment being furnished.
- 1.10 The successful TCC shall provide a fully functioning and commissioned temperature control system prior to the integration work that will be performed by Schneider Electric.
- 1.11 These apparatuses shall consist of, but not limited to, all necessary thermostats, sensing devices, valves, automatic dampers, damper motors, actuators, (except automatic dampers, valves, and damper motors furnished with HVAC equipment), and with the necessary accessories for the complete control of all equipment hereinafter specified.
- 1.12 Control sequences are specified at the end of this section. Provide all control equipment required to perform sequences described. Coordinate all dampers with the sheet metal contractor and equipment provider. It is the responsibility of the control contractor to ensure all required dampers in the sequence of operations are provided.
- 1.13 Coordinate flow meters, valves with mechanical contractor.
- 1.14 Include all power wiring and cabling for the operation of the controls system. Refer to Electrical Division Specifications for additional requirements.
- 1.15 Manufacturer's: Schneider Electric, Johnson Controls factory Branch Office, and Innovative Energy Solutions. These TCCs/manufacturers have prior approval with the Owner and Engineer and are the only allowed suppliers and/or installing TCCs.
- 1.16 The TCC shall have an established working relationship with the control manufacturer of not less than five years and shall have prior approval from the Owner and Engineer and are the only allowed suppliers and/or installing contractors. The TCC shall have a local office within 50 miles of the project site and provide service and/or replacement parts within a 24-hour notification of a control failure. The Building Management System contractor shall be staffed with engineers trained and certified by the manufacturer in the configuration, programming and service of the automation system. The contractor's technicians shall be fully capable of providing instructions and routine emergency maintenance service on all system components.
- 1.17 A mandatory pre-installation meeting shall occur prior to the TCC beginning any work on site. This meeting shall be attended minimally by Schneider Electric, mechanical contractor superintendent, TCC Superintendent, Engineer and Owner. The purpose of the meeting is to have the controls installer communicate their understanding of the system design and how the system is intended operate to the Engineer and get the Engineer's input and agreement. The agreement between the TCC and the mechanical engineer is to be thoroughly documented by the TCC for later reference.
- 1.18 The installation shall comply with the Local Authorities and State Fire Marshal code requirements, including normal operating and smoke mode functions (where applicable).

The installation shall comply with the requirements of the NEC, NFPA, UL and the Building Codes, including referenced mechanical, electrical, energy codes, etc.

1.19 Abbreviations

- TCC – Temperature Control Contractor
- BAS – Building Automation System

1.20 The TCC shall list the following cost breakdowns, material and labor, on the official project schedule of values:

- Controls shop drawings
- Controls materials and labor
- Controls startup, commissioning, testing, documentation
- Controls training and Owner acceptance

**PART 2 – ALLOWANCE:**

2.1 Northern Kentucky University has elected to utilize Schneider Electric as their System Integrator to connect controls provided under this contract with the existing Schneider Electric SmartStruxure Facility Management System front-end platform. The successful temperature controls contractor must utilize, contract and coordinate all system integration functions listed within this specification with Schneider Electric.

Schneider Electric contact information is as follows:

Ron Epp  
Schneider Electric  
9928 Windisch Rd  
West Chester, OH 45069

Direct: (513) 770-5716  
Cell: (513) 518-3927  
Email: Ron.Epp@Schneider-Electric.com

2.2 The integration allowance shall provide scheduling, alarm notification, reporting and complete graphic user interface for the entire facility.

2.3 It will be the responsibility of Schneider Electric to implement this project onto the SmartStruxure server with no adverse effect to the existing projects.

2.4 Allowance shall include mapping all the BACnet IP objects from the temperature control network controller and the power monitor to the SmartStruxure server/front-end system in the Physical Plant.

2.5 Allowance shall include mapping the utility meter into the SmartStruxure, where applicable.

2.6 The TCC shall provide all CAT5 or CAT6 cabling network cabling for utility meters TCP/IP connection. This shall include cabling to the Owner's data drops. The main system data drop will be provided by others.

**PART 3 - GENERAL SYSTEM REQUIREMENTS:**

- 3.1 All labeling for this system shall utilize actual final room names and numbers. The room names and numbers on the Contract Documents may not be the Owner's exact requirements. Coordinate with the Owner to insure compliance.
- 3.2 Include in the bid for the TCC to perform additional 40 on-site hours of on-site programming, adjustments, modifications, etc. as requested by the Engineer during the warranty period after the date of substantial completion for the project.
- 3.3 All points of user interface shall be on standard PCs that do not require the purchase of any special software from the control's manufacturer for use as a building operation terminal. The primary point of interface on these PCs will be a user interface.
- 3.4 The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system integrated utilizing ANSI/ASHRAE Standard 135-2001 BACnet, LONWorks technology, OBIX TCP/IP, MODBUS, OPC, and other open and proprietary communication protocols in one open, interoperable system
- 3.5 The TCC shall connect to any mechanical and electrical (power monitoring) equipment furnished with a control interface device. The TCC shall contact the equipment suppliers and/or manufacturers for information for the proper interface to the equipment being furnished. All points not provided with the equipment control interface are the responsibility of the TCC.
- 3.6 The operating system shall be based on a distributed control system in accordance with specifications. All building controllers, application controllers and all input/output devices shall communicate LonMark/LonTalk communication protocol. Network controller shall communicate via BACnet over Ethernet (IP). BACnet MS/TP is NOT an approved communication protocol.
- 3.7 The TCC contractor shall provide access to the system from a location determined by the Owner and from the Consulting Engineer's office (CMTA, Inc.). This shall include remote access requirements, set-up, passwords and any software necessary to access the BAS system.
- 3.8 The TCC shall all have access to various types of WEB browsers (i.e. Google Chrome, IE, etc.), which shall be included for access to the Direct Digital Control (DDC) system via the Owner's Wide Area Network (WAN) and/or Local Area Network (LAN).
- 3.9 The TCC shall be responsible for coordination with the Owner's IT staff to ensure that their system will perform in the Owner's environment without disruption to any of the other activities taking place on that WAN/LAN.
- 3.10 On Static pressure safeties during smoke purge, fireman override's etc., the Fire Alarm contractor shall be responsible for providing contacts and wiring to override applicable safety controls.

**PART 4 – SUBMITTALS:**

- 4.1 The TCC shall not start the project installation until the shop drawing submittals have been reviewed by the Engineer.
- 4.2 Submittals shall include hardware, end devices, ancillary control components, a written operating sequence, unitary control wiring, building floor plans showing communication cabling and labels as well as logic flow diagrams. All submittals shall be provided on paper and electronically in PDF format.
- 4.3 Submittals shall contain one control drawing per specified system and equipment. Drawing shall include point descriptors (DI, DO, AI, AO), addressing, and point names. Each point names shall be unique (within a system and between systems). For example, the point named for the leaving air temperature for ERU-BL1, ERU-BL2, ERU-BL3 shall not be LAT but should be named ERU-BL1 LAT, ERU-BL2 LAT, and ERU-BL3 LAT. The point names should be logical and consistent between systems and ERU's. The abbreviation or short hand notation (e.g., LAT) shall be clearly defined in writing by the TCC.
- 4.4 Control diagrams shall identify: System being controlled (attach abbreviated control logic text, all digital points, analog points, virtual points, all functions (logic, math, and control) within control loop, legend for graphical icons or symbols, definition of variables or point names and detailed electric connections to all control devices and sensors.
- 4.5 Points list shall include all physical input/output. Points list shall be provided in both hard copy and in electronic format and shall include: Name, address, engineering units, high and low alarm values and alarm differentials for return to normal condition, default value to be used when the normal controlling value is not reporting, message and alarm reporting as specified, identification of all adjustable points and description of all points.
- 4.6 Submittals shall contain floor plans depicting DDC control devices (control units, network devices, LAN interface devices, and power transformers as well as static pressure sensor in duct and temperature sensors in rooms) in relation to mechanical rooms, HVAC equipment, and building footprint.
- 4.7 Submittals shall contain DDC system architecture diagram indicating schematic location of all control units, LAN Interface devices, etc. Indicate address and type for each control unit, Indicate protocol, baud rate, and type of LAN per control unit.
- 4.8 Electrical wiring diagrams shall include motor start, control, and safety circuits and detailed digital interface panel control point termination diagrams with all wire numbers and terminal block numbers identified. Indicate all required electrical wiring. Provide panel termination drawings on separate drawings. Clearly differentiate between portions of wiring that are existing, factory-installed and portions to be field-installed.
- 4.9 Show all electric connections of the controls system to equipment furnished by others complete to terminal points identified with manufacturer's terminal recommendations.
- 4.10 TCC shall provide one complete drawing that shows the control-wiring interface with equipment provided by others.

- 4.11 Submittals shall include project specific graphic screens for each system including a picture of the screen with a list of the variables to be placed on the screen. (ALLOWANCE)
- 4.12 Submittals shall include TCC's hardware checkout sheets and test reports.
- 4.13 Submittals shall include the agenda for approval by the engineer and owner of the specified training periods. See training section for requirements.
- 4.14 Provide complete panel drawings that are:
  - Clearly labeled and schematic or drawn to scale.
  - Show the internal and external component arrangement so that the operators can identify the components by their position if the labels come off.
  - Wiring access routes shall also be identified so that Class 1 wiring is separated from Class 2 and 3 and so high voltage wiring is segregated from low voltage wiring.
  - Complete identification of all control devices (manufacturer's type, number, and function).
  - Provide details for labeling all wiring, control devices, and controllers.
  - Material and equipment descriptive material such as catalog cuts, diagrams, performance curves, and other data to demonstrate conformance with specifications shall be provided.
- 4.15 Include room schedule including a separate line for each terminal unit, heat pump, etc. indicating location and address.

**PART 5 – O&M MANUALS AND CLOSEOUT DOCUMENTS:**

- 5.1 Refer to Mechanical Specification Section – REQUIRED SHOP DRAWINGS, ETC. for additional requirements.
- 5.2 Operating instructions, maintenance procedures, parts and repair manuals shall be supplied. Repair manuals shall include detailed instructions in the setup, calibration, repair and maintenance of all equipment furnished. Also supplied with these manuals will be a complete parts listing of all devices supplied which is to include part numbers and model numbers of all parts and component parts along with exploded views of devices.
- 5.3 All as built drawings (wiring diagrams, flowcharts, floor plans, etc.) shall also be supplied to the owner electronically in PDF format.
- 5.4 System specific wiring, control diagrams, sequence of operation and points lists shall be as installed in each control panel. This means as-built drawings, not design (submittal) drawings.
- 5.5 Supply all software necessary for configuration of, modification, editing or communicating to any of the unitary devices. Software shall be capable of uploading and down-loading the entire unitary data base or any part of the automated system for backup or archiving.
- 5.6 Supply one copy of the software programming manual (hard copy and PDF format). The manual shall describe all furnished software. The manual shall be oriented to programmers and shall describe calling requirements, data exchange requirements, data file requirements,

and other information necessary to enable proper integration, loading, testing, and program execution.

- 5.7 Provide a Bill of Materials with each schematic drawing. List all devices/equipment and match to schematic and actual field labeling. Provide quantity, manufacturer, actual product ordering number, description, size, accuracy, operating ranges (voltage, temperature, pressure, etc.), input/output parameters, etc.
- 5.8 Maintenance manual shall include copies of signed-off acceptance test forms, commissioning reports, start-up reports, etc.
- 5.9 The TCC shall turn over to owner two (2) sets of electronic back-ups of the complete temperature control system.

**PART 6 – WARRANTY & SOFTWARE LICENSES:**

- 6.1 Labor and materials for the control system specified shall be warranted free from defects for a period of 24 months after substantial completion and acceptance. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Owner.
- 6.2 The TCC shall respond to the Owner's request for warranty service within 24 hours during normal business hours. The TCC shall respond to the Owner's request for Emergency service (defined as life-threatening or creating the potential to cause property damage) during the warranty period within 4 hours.
- 6.3 The TCC shall provide technical phone support to the owner during the warranty period for warranty related issues and for two years after the warranty period. If the technical support location of the TCC is outside of the toll-free calling area for the customer, the TCC shall have a toll-free number or accept collect calls for the purpose of providing technical support.
- 6.4 During the warranty period, standard parts for the DDC system shall arrive at the facility within 48 hours of placing an order. Non-standard parts (requiring re-manufacturing or ordering from another supplier) shall be shipped within 96 hours.
- 6.5 Operator workstation software, project-specific software, graphic software, database software, and firmware updates which resolve known software deficiencies as identified by the TCC shall be provided and correctly installed at no charge during the warranty period.
- 6.6 Provide licensed electronic copies of all software for each workstation, laptop, and server. This includes, but is not limited to: project graphic images (editing/modifying/creating), project database, trouble-shooting and debugging programs, project-specific programming code and all other software required to operate and modify the programming code (including software at system level, primary control units, secondary control units, and all communication software). Any hardware devices (cables, protection devices) required to operate the software/hardware shall also be provided.
- 6.7 All additional licensing needed for this project shall be supplied by TCC. Software license shall not expire or utilize any sort of protection hardware device for its use. In any case owner shall be free to direct the modification of any software license, regardless of supplier

to allow open access to all controllers. Owner shall hold the software and firmware licensing. Software license shall not expire or utilize any sort of protection hardware device for its use.

- 6.8 System software shall be the latest version available with upgrades provided at the end of the warranty period, and shall be fully licensed to the Owner for the entire system. Supply all software necessary for configuration of, modification, editing or communicating to any of the unitary devices. Software shall be capable of uploading and down-loading the entire unitary data base or any part of the automated system for backup or archiving. Software shall be "IBM compatible".

#### **PART 7 – TRAINING:**

- 7.1 A formal on-site "Hands On" training session shall be conducted for the owner's maintenance personnel. This session shall be a minimum of one (1) eight (8) hour (3 (three) hours in classroom training and 5 (five) hours in field training) days to train the staff on setup, operation, and maintenance of all system(s) and/or devices. This will be at a time and location selected by the owner. All training materials and books shall be provided. Training sessions shall be given by the manufacturer's "factory" technical representative. (This is defined as someone other than the installing contractor's representative.) All expenses are to be provided by the TCC. Training session shall be scheduled at owner's request.
- 7.2 TCC shall conduct training courses for designated personnel in operation and maintenance of system. Training shall be oriented to specific system being installed under his contract and shall be digitally recorded and submitted on DVD by the TCC.
- 7.3 Training shall be a mix of, test exercises, and actual keyboard entry and screen viewing at the operator's terminal. A curriculum shall be discussed and implemented based on the level of expertise of the employees. Hands-on experience and problem solving shall be emphasized.
- 7.4 If during any training session, the trainer/owner finds more than three (3) items that need repair, the training session will be immediately terminated. The session will be rescheduled for another date. The re-scheduled training session will be carried out at no additional cost to the Owner.
- 7.5 The training shall be oriented to making the owner self-sufficient in the day-to-day use and operation of the DDC system.
- 7.6 Additionally, the training shall include:
- System start-up, shutdowns, power outage and restart routines, alarms, security levels, changing setpoints, changing schedules and other parameters, overrides, freeze protection, manual operation, return to automatic operation, and resetting equipment.
  - All screens shall be discussed, allowing time for questions.
  - Information specifically focused on showing the owner methods of troubleshooting the mechanical systems using the DDC.
  - Use of laptop and hand-held operator interface device, if applicable.
  - Remote access to the system.
  - The other training sessions shall be oriented toward answering specific questions from Owner's staff.

- The trainer must be well grounded in both DDC system operation and in mechanical systems service and shall be the programmer.
- 7.7 This documentation and process shall be complete, approved and accepted by Engineer and Owner prior to acceptance. This information shall be documented as completed. A copy shall be delivered to the Engineer and Owner and included in the O&M manuals.
- 7.8 Coordinate training schedule with the project commissioning agent.

**PART 8 – NOT USED**

**PART 9 – WIRE MANAGEMENT, ELECTRICAL POWER, ETC:**

- 9.1 Refer to CABLING section of this specification for additional requirements.
- 9.2 Electrical work required for system interlock and installation of the temperature control system shall be included in the bid and installed per all applicable codes. Coordinate with other trades as required for installation of a complete system.
- 9.3 All wiring and cabling in mechanical and electrical rooms shall be in conduit. No wiring or conduit can be exposed to view in any other area. Conceal all wiring and cabling in conduit in wall from thermostats or other controls devices to above ceiling. Install conduit in wall from wall thermostats to above ceiling for cabling. Route wiring directly to cable tray from control points above the ceiling. Rough-in for control devices shall be in compliance with the requirements of the ELECTRICAL SPECIFICATIONS.
- 9.4 Any power for controls shall be fed from dedicated circuits in emergency electrical panels, when provided for a project, and shall not be obtained from receptacles, lighting, or equipment circuits. Unitary control power may be obtained from the equipment served. If power is obtained from the equipment served, the power may not be interrupted to the electronics if the equipment is off for any reason.
- 9.5 Electrical trade to provide all necessary 120vac emergency/normal circuits required for BAS control panel power in each mechanical room where BAS panels are located. BAS controls contractor to extend the 120vac circuits from central location in mechanical room to each BAS control panel.
- 9.6 The TCC shall be responsible for the power source to any control panels, unitary controllers, etc. on any controlled equipment and all other control power requirements. This includes circuit breakers, wiring, conduit, etc. installed in strict accordance with NEC. The TCC may contract with the electrical contractor for the power wiring installation.
- 9.7 Prior to installation, insure through coordination with all trades, that appropriate clearances (36" minimum) as required by the N.E.C. are maintained at all control panels, including unitary controllers for terminal units, etc.
- 9.8 The TCC shall provide all CAT5 or CAT6 cabling network cabling for a complete system. This shall include cabling to the Owner's data drop. The main system data drop will be provided by others.

- 9.9 All control circuits within the electrical panels shall be marked to indicate equipment served.
- 9.10 The TCC shall perform all temperature control interlock wiring. This shall include control valves, dampers, thermostats, indoor/outdoor HVAC systems, etc. Electrical work required for system interlock and installation of the temperature control system shall be included in the bid and installed per all applicable codes. Coordinate with other trades as required for installation of a complete system.
- 9.11 The TCC shall be responsible for any power required for the unitary controls or control panels. This includes circuit breakers, wiring, conduit, etc. installed in strict accordance with NEC. The TCC may contract with the electrical contractor for the power wiring installation.
- 9.12 Provide one duplex outlet mounted inside the control panel and separately fused with a non-time delay fuse at 15 A at any panel location containing electronic control components. This receptacle may be served from the control panel 120 VAC power source.
- 9.13 All wiring shall be continuous runs. Any junctions must be made in metal enclosure.
- 9.14 Grounding terminals shall be color coded green and yellow and shall be compatible with the other specialty terminals specified above and shall mount on the same DIN rail system. Units shall be arranged so that the wiring connected to them is grounded to the enclosure via the mounting rail. These terminals shall be provided for grounding cable shields at the points where the cables enter a control panel and terminate on the control panel terminal strip. Terminals shall be Entrelec M 4/5.3A.PI or equivalent by Weidmuller, Phoenix, or Allen Bradley.
- 9.15 Contractor shall insure control panels have an identification label stating the "Certification Agency" such as UL, CSA, CE, etc.

**PART 10 – CABLING:**

- 10.1 Refer to WIRE MANAGEMENT section of this specification for additional requirements.
- 10.2 ALL CONTROL WIRING SHALL BE INSTALLED IN A WIRE MANAGEMENT SYSTEM TO INCLUDE CABLE TRAYS, BRIDLE RINGS, & CONDUITS. NO EXCEPTIONS! COORDINATE WITH ELECTRICAL CONTRACTOR TO INSURE A COMPLETE WIRE MANGEMENT SYSTEM.
- 10.3 Acceptable cable manufacturers are Belden, West Penn or Alpha, or approved equal.
- 10.4 A complete cabling system shall be furnished and installed, which shall adhere to the highest workmanlike standard of quality and appearance. Cabling shall be installed square with building lines and contained within a wire management system.
- 10.5 All sizing of cabling shall be according to manufacturer's recommendations, but shall be a minimum of 18 AWG.
- 10.6 Furnish a floor plan of the building indicating communication cable labeling and routing as well as addresses and branch wiring from the unitary devices. All cabling shall be labeled on

both ends. The type, size and label of all cabling shall be indicated on submittal floor plan drawings.

- 10.7 Wall space temperature sensor cabling (from the sensor to the unitary controller) shall have a minimum of four (4) conductors.
- 10.8 All cabling shall be stranded. "NO" solid conductors will be accepted. All cabling shall be 100% shielded with appropriate drain wire and insulation.
- 10.9 All cable connections shall be continuous run (including shield). Any junctions must be made in a metal enclosure, connections must be soldered, taped and the metal enclosure must be mechanically attached to the nearest ground. No wire nuts or crimped connections will be accepted. Note location of junction boxes on the as built floor plans. All cabling networking unitary controllers, and other networked equipment, shall be in soldered.
- 10.10 All shields must be terminated as per manufacturer's recommendation. Shield termination requirements by the manufacturer must be provided with submittals.
- 10.11 Wireless controllers are not approved.

**PART 11 – SYSTEM SOFTWARE:**

- 11.1 System software will be the latest version available with upgrades provided for full warranty period, and shall be fully licensed to the owner for all network controllers and servers. Refer to WARRANTY section of this specification for additional requirements.
- 11.2 System software shall, at a minimum, provide:
  - Monitor and supervise all control points.
  - Add new points and edit system database.
  - Change control setpoints, timing parameters and loop tuning of PID coefficients in all control loops in all control units.
  - Enter programmed start/stop schedules.
  - Modify existing control logic (or sequence of operation) in all control units.
  - Upload/Download programs, databases, control parameters, etc.
- 11.3 Sequence of operation programming methodology - The application software shall be user programmable. Application programming shall be (1) Line type programming that uses text programming in a language similar to BASIC or FORTRAN, or (2) graphical block programming - The method of programming shall be by manipulation of graphic icon "blocks." Each block represents a subroutine containing the programming necessary to execute the function of the device that the block represents.
- 11.4 Unitary Control Unit Database Archiving - The host software shall provide capability to upload sequence of operation, database, and other control parameters from each controller. Uploaded programs shall be retained on hard disk for system backup. Programs may be modified using Editor functions, and downloaded to individual controllers as desired. Downloading of databases shall not interrupt other multi-tasked functions that are ongoing.
- 11.5 Third Party Software Packages - The host software shall provide the capacity to run third party software packages for word processing, spreadsheets, or database management

programs. Use of third-party software shall not suspend operation of background tasks of multi-tasking operating system, such as alarm logging, and report generation.

**PART 12 – COLOR GRAPHIC DISPLAYS (ALLOWANCE):**

- 12.1 Scheduling provided by the allowance.
- 12.2 The color graphics shall reside on the Schneider SmartStruxture server and are included in the allowance. All graphics shall be consistence with NKU graphic standards.
- 12.3 All graphics screens shall be submitted for review by Engineer. Provide the following animated, color graphics screens minimally:
- 12.4 Entire floor plan home screen with OAT, Time and Date displays.
  - Floor plan showing major zones,
  - Graphics shall include a floor plan with zone temperature and a matrix view for each floor showing room number: Terminal Unit Number, Room Number, CFM, Space Temperature, Discharge Air Temperature, and Heating/Cooling mode.
  - Click major zone displays enlarged floor plan of the zone showing individual terminal unit zones & numbers. Include link to respective mechanical room.
  - Click individual zone shows terminal unit graphic. Display all data points from points list, occ/unocc schedule and setpoints, OAT, Time and Date.
- 12.5 Color Graphic Screens to match existing shall be designed the Dashboard in the Steam Plant and shall include the following:
  - Electric power metering demand and consumption
  - Gas meters demand and consumption
  - Domestic water demand and consumption
- 12.6 Color Graphic Screens shall be designed for all mechanical systems and shall include the following:
  - A graphic shall be the starting page with the building graphically indicated. Break up the floor plan into zones to match Contract Documents. The building shall be the point of reference to enter into the respective building control system.
  - All terminal equipment including VRF indoor units, VRF refrigerant controller units, VRF outdoor units, etc.
  - All ERU units.
  - Domestic hot water heaters and pumps.
  - The summation of all supply OA for each unit shall be displayed on the ERU graphic pages.
- 12.7 Graphics to include floor plans with room numbers (as-built room numbers) and thermostat locations, links to flow diagrams for VRF system, VRF indoor units, outside air systems, domestic hot water and lighting controls.
- 12.8 All new graphics shall match the existing system graphics, unless noted otherwise.
- 12.9 The graphical programming software shall allow for interactive mouse-driven placement of block icons on the graphic screen and connection of block inputs to block outputs by means of drawing lines to form a graphic logic diagram. The user shall not have to manually input

text to assign block input/output interconnections. Blocks shall allow entry of adjustable settings and parameters via pop-up windows.

- 12.10 Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.
- 12.11 All data fields must indicate a unit of measure; DegF, %, ppm, etc.
- 12.12 The clarity of sequence shall be such that the user has the ability to verify that the system programming meets the specs without having to learn or interpret a manufacturer's unique programming language. Provide a means for testing and/or debugging the control programs off-line (not communicating with control units) using operator entered values for physical inputs and time. Provide a means for testing and/or debugging the control programs on-line (communicating with control units), showing actual physical inputs and all block outputs in real time.
- 12.13 Provide a utility that shall allow the graphic logic diagrams to be directly compiled into application programs. Logic diagrams shall be viewable either off-line, or on-line with real-time output values.
- 12.13.1 Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression. Operators must be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.
- 12.14 All graphic software shall be in the html web browser format and support multiple simultaneous screens to be opened and resizable in a "Windows" type environment. All functions, except text entry, shall be executable with a mouse. Graphic software shall provide for multitasking such that third-party programs can be used while the Operator Workstation Software is on-line. Provide the ability to alarm graphically even when operator is in another software package. The software shall allow for Owner to create user defined, color graphic displays of geographic maps, building plans, floor plans, and mechanical and electrical system schematics.
- 12.14.1 The contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, filters, dampers, etc.), mechanical system components (e.g., terminal units, etc.), complete mechanical systems (e.g. VRF, etc.) and electrical symbols. It shall be possible to create and save graphical components and JavaScript code in reusable and transferrable, customized libraries.
- 12.14.2 All applicable control points must have "Forced by Operator" or "Manual Mode" properties that are clearly displayed on individual graphic pages for each point accessible from the graphic page. This is displayed by a "M" in the data field.
- 12.15 The graphic development package shall use a mouse or similar pointing device to allow the user to perform the following:
  - Define symbols
  - Position items on graphic screens
  - Attach physical or virtual points to a graphic
  - Define background screens
  - Define connecting lines and curves

- Locate, orient and size descriptive text
  - Define and display colors for all elements
  - Establish correlation between symbols or text and associated system points or other displays.
  - Create hot spots or link triggers to other graphic displays or other functions in the software
- 12.16 The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse.
- 12.17 A matrix view for all Heat Pump units must be provided in addition to individualized Heat Pump unit pages. Geothermal Heat Pump Graphics must:
- Have an individual graphic page along with a floor/building matrix page
  - Provide linking between individualized Heat Pump unit pages to the floor plan and the conceding matrix page. Linking must also be established to previous and succeeding Heat Pump units through the use of up/down arrows.
  - All Heat Pump unit fans, pumps, heating and cooling controls need to be force-able at the operator's discretion from the graphic pages.
  - "Global" Heat Pump unit setpoints to multiple HPs shall be performed from a single location on the graphics page.
  - Each graphic page must be individualized; a "Master" may not be used as a template for similar zones/controllers so that zone or area specific instructions/notes can be added to each graphic.

### **PART 13 – ALARMS AND TRENDS (ALLOWANCE)**

- 13.1 Scheduling provided by the allowance
- 13.2 The alarms and trends shall reside on the Schneider Smartstructure server or the Schneider I/NET server and are included in the allowance. All alarms and trends shall be consistence with NKU standards.
- 13.2.1 All alarms must be displayed in the alarm queue and also on the coinciding graphic page with a red flashing alarm indication in the data field and/or similar graphic presentation.
- 13.2.2 Status changes or alarm conditions must be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another. Start/Stop and Status points must indicate a graphical and color change in state, (green to black) or similar presentation using the same color scheme.
- 13.3 All temperature sensors must have a High- & Low-Level Alarm Limit Set. These alarms limits shall be discussed with NKU prior to implementation of programming of resident I/O's
- 13.4 Trending of control points must be available on all control & monitoring points and accessible through graphic pages. Ability to add and delete trending data shall also be made available through graphical displays.

- 13.5 The TCC shall including programming of point trends as directed by the Engineer. These can be requested at any time during the project including the warranty period. Trend “change of state” for digital inputs. Trend analog points in 30-minute increments. Maintain trend history for 30 days. Trend of gas and electrical power and shall start on same day as utility billing cycle. Include the following:
- Outside air temperature
  - OA unit leaving air temperatures for each ERU unit
  - VFD speeds (OA & EA)
  - Gas Mcf
  - Domestic hot water supply temperatures
  - Electrical power kW and kWh
  - Others as directed in the field

#### **PART 14 – SYSTEM ARCHITECTURE**

- 14.1 The Building Automation System (BAS) shall consist of Network Controllers and a family of Standalone Digital Control Units.
- 14.1.1 The system shall be designed with a top-level 10/100bT Ethernet network, using the BACnet/IP. A sub-network of Standalone Digital Unitary Controller using the LonTalk FTT-10A, and/or Modbus RTU protocol shall connect the local, stand-alone controllers with Ethernet-level Network Server Controllers/IP Routers.
- 14.1.2 All Network Controllers shall be capable of residing directly on the owner's Ethernet TCP/IP LAN/WAN with no required gateways. Furthermore, the Network Controller shall be capable of using standard, commercially available, off-the-shelf Ethernet infrastructure components such as routers, switches and hubs. With this design the owner may utilize the investment of an existing or new enterprise network or structured cabling system. This also allows the option of the maintenance of the LAN/WAN to be performed by the owner's Information Systems Department as all devices utilize standard TCP/IP components.
- 14.1.3 Gateways are not approved on this project.

#### **PART 15 – NETWORK CONTROLLER**

- 15.1 The University's existing enterprise level control system between buildings shall maintain TCP/IP for communications of building data with the server-based graphical user interface and enterprise information system. Coordinate with the university's IT department on locations for Ethernet communication cabling and TCP/IP addresses. It is intended to minimize control system traffic over the University's shared Ethernet network. IT is intended that only one Network “Building Level” Controller and its associated TCP/IP address be used per building. Each building shall have its own subnet and Broadcast Management Device (BBMD). The University shall provide the Ethernet switch and port. No other IP switches shall be permitted. The TCC shall provide raceway for the University provided cabling between the switch and the Network “Building Level” Controller. Control systems shall not rely on University Ethernet communications for control sequences.
- 15.1.1 The TCP/IP layer connects all of the buildings on a single Wide Area Network (WAN) isolated behind the campus firewall. Fixed IP addresses for connection to the campus WAN shall be used for the Network Controller that connects to the WAN.

- 15.2 Install the Network Controller in a surface mounted panel, NEMA type 12 enclosures, with a removable hinged door. Provide a flush mounted key lock. All control panels must be painted the same color and identified. The boxes are to be made from 16-gauge material. Panels should not be provided with knockouts.
- 15.3 For each panel, provide a UPS power supply to help with brief power outages and power surges
- 15.3.1 Web-based operation shall be supported directly by the Network Controller and require no additional software, other than a Java supported network browser.
- 15.4 Control panels shall be constructed by a UL approved panel manufacturer. The standard used shall be UL508A. All proper labels are to be attached. Panel shall meet the requirements of UL512 and be arc flash compliant panels.
- 15.5 The Network Controller shall be web-based and communicate BACnet IP. It shall issue all time schedules, summer/winter commands, customized trending, holiday scheduling, alarm handling, clock or other shared commands to all unitary controllers within the building network. If for any reason communications between the unitary(s) and the Network Controller is lost, the unitary(s) shall operate in a stand-alone manner (in day operation) until communications is restored. It shall also operate in the "summer" or "winter" mode as last commanded.
- 15.6 The Network Controller shall be integrated and interoperable with the facility infrastructure and include user access to all system data locally over the Local Area Network (LAN) / Wide Area Network (WAN) within the building and remotely by a standard Web Browser over the Internet. Any computer connected to the network, utilizing a web browser and having the proper password.
- 15.7 The Network Controller shall be a fully user-programmable, supervisory controller. It shall monitor the network of distributed unitary controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Controllers.
- 15.8 The Network Controller shall have UPS back-up to allow a minimum of seven days of operation. The Network Controller shall be composed of one or more independent, stand-alone, microprocessor to manage the network strategies described in Application software section. The network controller shall have ample memory to support its operating system, database and programming requirements. The operating system of the Network Controller shall manage the input and output communications signals to allow distributed unitary controllers to share real and virtual point information and allow central monitoring and alarms. The database and custom programming routines of the Network Controller shall be editable from a single operator station.
- 15.9 The Network Controller shall be remotely monitored via the internet. Additionally, it shall include automatic emailing and texting out alarms, gathering alarms, reports and logs, programming and downloading database.
- 15.10 The Network Controller shall continually check the status of all processor and memory circuits. If a failure is detected, the controller shall:

- Assume a predetermined failure mode.
  - Emit an alarm.
  - Display card failure identification.
- 15.11 Under no circumstance shall more than 75% of the total number of sensor and control points be connected through a single Network Controller. Each DDC system component shall provide for the future addition of at least 20% of each type of the number of sensor and control points connected to that component including a minimum of one universal input and one universal output.

## **PART 16 – UNITARY CONTROLLER**

- 16.1 Unless otherwise specified, each piece of equipment shall have its own Unitary Controller (i.e., heat pump, AHU, terminal unit, etc.). The Unitary Controller for each piece of equipment shall be mounted on the side of the unit. The Unitary Controller for all other equipment shall be mounted in a panel and properly labeled.
- 16.1.1 Panels in mechanical rooms subject to water damage from above shall be installed in a surface mounted panel, NEMA type 12 enclosures, with a removable hinged door. Provide a flush mounted key lock. All control panels must be painted the same color and identified. The boxes are to be made from 16-gauge material. Panels should not be provided with knockouts. NEMA 1 panels are acceptable in remaining locations.
- 16.2 Each Central Station Air Handler and/or Outside Air Unit shall have its own Unitary Controller mounted where shown on the drawings. If an installation location is not clear, the Contractor shall notify the Engineer for clarification prior to installation.
- 16.3 Unitary Controllers used in conditioned ambient shall be mounted in dust-proof enclosures, and shall be rated for operation at 32 degrees F to 120 degrees F. All Unitary Controllers shall have an RJ-11 or similar type connection for monitoring or programming access by room or local equipment level with access to any unitary within the network without modification.
- 16.4 Control panels shall be constructed by a UL approved panel manufacturer. The standard used shall be UL508A. All proper labels are to be attached. Panel shall meet the requirements of UL512 and be arc flash compliant panels.
- 16.5 Unitary Controllers utilized in the network shall have full standalone capability including time of day and holiday scheduling as well as all energy management functions such as optimal start/stop, duty cycling, etc. The terminal unit Unitary Controllers may be pre-programmed with the project specific sequence of operation as specified for the application. Any re-programming of the electronics shall be performed on location using a portable personal computer with appropriate software or through the Network Controller. The entire unitary data base shall have the capability of being backed up and or downloaded locally.
- 16.6 All points to have a unique digital input to the BAS system. The use of digital point count expanders is not an acceptable replacement to digital inputs to the unitary controller. The conversion of a single universal input channel to accept up to multiple voltage free contacts

such as relay contacts, auxiliary starter contacts, differential pressure switches, etc. IS NOT ACCEPTABLE.

- 16.6.1 The Fieldbus layer shall be supporting all of the following types of Standalone Digital Unitary Controller's:
  - 16.6.1.1 LonWorks Standalone Digital Unitary Controller requirements: The system shall consist of one or more LonWorks FTT-10A field buses managed by the Network Controller. Minimum speed shall be 76.8kbps. The field bus layer shall use peer-to-peer, event-driven communication for operation of HVAC and lighting equipment.
  - 16.6.1.2 Modbus Standalone Digital Unitary Controller requirements: The system shall consist of one or more Modbus RTU (RS-485 or RS-232) field buses managed by the Network Controller.
- 16.7 All Unitary Controllers shall be fully application programmable. All control sequences within or programmed into the unitary controller shall be stored in non-volatile memory, which is not dependent upon the presence of a battery shall be retained.
- 16.8 Unitary Controllers shall have a 10% spare point capacity to be provided for all applications.
- 16.9 The Unitary Controller for each VAV box shall be mounted on the side of the unit. The unitary controller for all other equipment shall be mounted in a panel and properly labeled. Prior to installation, insure through coordination with all trades, that appropriate clearances (36" minimum) as required by the N.E.C. are maintained at all control panels, including unitary controllers for VAV terminals, etc.
- 16.10 After a power failure, the Unitary Controller shall operate the control application using the current setpoints and configuration. Reverting to default or factory setpoints are not acceptable.

#### **PART 17 – SENSORS AND MISCELLANEOUS DEVICES:**

- 17.1 WEATHER STATION HOUSING: Provide Kele Model A21 Outdoor Aspirated Humidity/Temperature housing. NEMA 3R enclosure is painted white to reduce the effect of radiation, and the enclosure has a lockable latch for security. The outdoor air sensor will be installed on the north wall in the shade as not to be affected by sunlight, building ventilation or weather. This location shall be indicated on the control drawings. Installation in outside air ductwork or louvers is not acceptable. If not installed to provide "accurate" temperature readings, it shall be relocated (at the TCC's expense) until a suitable location is found.
- 17.2 SENSOR RESOLUTION: All temperature sensors shall have a minimum resolution of 1/10th of 1-degree F. (0.1-degree F.) Sensor stability shall be 0.24 degrees over a year period. Space sensors shall be tested and accurate to within 0.75 degrees F. Outside air, water and duct sensors shall be tested and accurate to within 2.0 degrees F.
- 17.3 SPACE SENSORS AND THERMOSTATS:
  - Refer to the drawings for proper type and location.
  - All temperature sensors/thermostats shall be typical to those used currently throughout the campus.

- Suite Room (Units), Study Room, Office thermostats: Programmed set-point shall be locally adjustable, limited to 2 degrees above set-point and 2 degrees below set-point. Thermostats must have blank cover with no LCD display.
  - Common Area 120 and Lounges: Thermostat must have blank cover with no LCD display and non-adjustable set-point.
  - Resident Manager Apartment thermostat: Programmed set-point shall be locally adjustable, limited to 4 degrees above set-point and 4 degrees below set-point. Thermostat to display Operation Mode,
  - Generally, thermostats/sensors shall be installed 5'-0" above the finished floor.
  - ADA rooms, thermostats/sensors shall be installed 4'-0" above the finished floor.
  - Where thermostats/sensors are to be mounted next to a light switch, install at the same height as the light switch.
  - Sensors in hallways, vestibules, stairways, restrooms, and utility rooms shall utilize a stainless steel surface mount temperature sensor installed on an interior wall or partition (2"x4" blank plate). Care must be taken in the installation of these sensors to ensure proper insulation from the wall temperatures in order to properly sense space temperature.
  - If there is a question consult engineer prior to rough-in.
- 17.4 WATER SENSORS: Temperature sensors for water lines are to be the well type. Wells are to be threaded brass (same manufacturer as the temperature sensor) with the sensor coated with a heat transfer compound. Strap on sensors will not be acceptable.
- 17.5 DISCHARGE AIR AND DUCT ROOM RETURN AIR SENSORS: Shall be rigid insertion type. In all applications, care shall be taken to insure that the sensors are securely mounted as not to allow any vibration and installed in such a manner as to indicate the truest possible temperature.
- 17.6 COMBINATION TEMPERATURE/HUMIDITY SENSORS: All temperature sensors shall have a minimum resolution of 1/10th of 1-degree F. (0.1-degree F.) Sensor stability shall be 0.24 degrees over a year period. Space sensors shall be tested and accurate to within 0.75 degrees F. The humidity sensing device shall be 100% solid state, linear and temperature compensated with a 0-100% RH range. The response time shall be a minimum of 30 seconds for a 60% change. They shall have a minimum of 2% accuracy minimum accuracy of +/-2% RH minimum rangeability 5 to 95% RH non-condensing and maximum hysteresis +/-1.5% RH – Do not submit products that do not meet this range. The output of the device must utilize a 0-10 VDC or 4-20mA signal as required. The device must use a power supply of 24 VAC or VDC. Duct mounted sensors shall have at least 4" insertion probe with a 16-gauge steel enclosure. NIST traceable certification shall be provided to the Engineer as part of the shop drawings. For wall mounted sensors the enclosure shall be polystyrene plastic mounted next to and at the same height as the temperature sensor in that area. Both shall have the same appearance. Provide protective cages in fitness and common areas.
- 17.7 LOW PRESSURE TRANSDUCERS: These devices shall be 100% solid state, linear and temperature compensated. Accuracy shall be no less than plus or minus 1% of its full range. Linearity, repeatability and hysteresis shall be no less than plus or minus 0.1%. All pressure sensors shall utilize output averaging/output clipping to adjust and stabilize any fluctuations in the output. The output of the device shall utilize a 0 - 10 VDC signal. The device shall use a power supply of 24 VAC or VDC. The enclosure 16-gauge steel. For

sensing internal static pressure of air handling ducts utilize sensors with a range of 0 to 5 inches water column. For sensing building static pressures (building compared to atmospheric) utilize a sensor with a range of -0.25 to +0.25 inches water column.

- 17.8 RELAYS: Relays for starting and stopping fractional horsepower motors shall be rated as follows:
- 1/4 horsepower motors or less use 15 ampere rated relays,
  - 1/3 horsepower motors use 20 ampere rated relays,
  - 1/2 horsepower motors use 30 ampere rated relays,
  - Relays used for pilot duty service shall be rated at a minimum of 10 amperes.
  - Provide auxiliary pilot duty relays on motor starters as required for control function.
  - Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.
- 17.9 CURRENT SENSING DEVICES: Veris Industries model Hx08 Series and H701 or equal. All current sensors shall be capable of alarming to the BAS for belt losses, pump coupling shear or other mechanical failure on loads.
- 17.10 NATURAL GAS METER: Sage Integral Prime In-line style with NPT end connections Model Number SIP-\_\_\_\_-DC24-NG. Coordinate Flow body sizing with manufacturer.
- 17.11 SINGLE DIRECTION WATER FLOW METER: Onicon Model F-1200 series dual turbine insertion flow meter. 50:1 turn down with 2% accuracy with 0.4 to 20 fps range. Install flow meter with sufficient pipe diameters as recommended by manufacturer. Provide factory authorized start-up verification of operation and calibration. Provide with remote display where indicated.
- 17.12 DIFFERENTIAL PRESSURE TRANSMITTERS: Provide Rosemount (ITT Bell & Gossett ST-102R) or Johnson Controls Setra DPT 2302-050-V field mounted differential pressure sensor transmitters as indicated on the plans. Range shall be 0-25 psig. Accuracy shall be .025% full span.

#### **PART 18 - VALVES, DAMPERS AND ACTUATORS:**

- 18.1 Dampers for various units requiring field mounting shall be tight closing, "ultra-low leakage", opposed blade with side and edge seals. They shall be sized and furnished under this section. Installation of dampers shall be by the sheet metal contractor, coordinated by the TCC. Frames shall be no less than 16 gauge galvanized steel and furnished with mounting holes for duct mounting. Damper blades shall be no less than 14 gauge galvanized steel with maximum blade width of 8 inches. Blades shall be secured to 1/2 inch zinc plated axles and hardware with nylon bearings. Provide thrust bearings at the end of each blade. All dampers shall have end switches to positively prove damper position. No Exceptions!
- 18.2 "ALL" Actuators shall be of the same manufacturer and have internal feedback circuitry to provide a positive action to insure proper positioning of the damper or valve through the entire sequence. Actuators shall have an adjustable starting point to accurately set the range

of travel to the output of the controller. All actuators shall also utilize the same input signal (6-9 VDC, 0-010V, 2-10 VDC, 4-20 MA) in order to maintain some consistency in the control application. Analog actuation is 6-9 VDC, 0-010V, 2-10 VDC or 4-20 MA, floating point control with 2 digital outputs is NOT approved as analog actuation.

- 18.3 Actuators may be factory installed. If not, factory installed, they shall be installed as per instructions by the terminal equipment manufacturer.
- 18.4 Locations mounted above ceiling shall be marked on ceiling grid.
- 18.5 Install damper motors on the outside of the duct in warm areas where possible, not in air stream or locations exposed to outdoor conditions.

**PART 19 - VARIABLE FREQUENCY DRIVES (VFDs):**

- 19.1 The work includes all labor, materials, and related items to completely furnish and install, start up and test, and place into service the Variable Frequency Drives (VFDs) indicated and scheduled on the Drawings and described in the Specifications.
- 19.2 VFDs shall be as manufactured by ABB or approved equal. This is the only acceptable manufacturers. All VFDs for the project shall be by the same manufacturer (no exceptions).
- 19.3 VFDs shall be consist of a pulse width modulated (PWM) inverter designed for use on a standard NEMA Design B induction motor.
- 19.4 The VFD shall be capable of operation form AC voltage in two rages 208–240 VAC  $\pm$  10%, or 380–480 VAC  $\pm$  10%. 50/60 HZ operation,  $\pm$  2 hertz.
- 19.5 The VFD enclosure shall be rated UL type 1 and shall be UL listed as a plenum rated, suitable operating conditions: 0 – 40<sup>0</sup> C continuous. Drives that have thermal cut out circuits, or that cannot operate continuously at 40<sup>0</sup> C shall not be acceptable. Altitude 0 to 3300 feet above sea level, up to 95% humidity, non-condensing.
- 19.6 The VFD shall produce an adjustable AC voltage/frequency output for step less motor speed control utilizing sine wave coded Pulse Width Modulation (PWM) The Drive shall provide automatic power factor correction and a .98 displacement power factor by incorporating a full wave diode bridge rectifier. The VFD shall have an overload rating of 110% of nominal rated current for 1 minute out of every 10 minutes of operation, which is an acceptable overload for centrifugal loads.
- 19.7 The VFD shall include a built-in first environment RFI/EMI filter and be CE and UL labeled. It shall also meet the CE requirement of EN61800-3 which provides an actual test procedure that shows that the VFD is immune from RFI/EMI interference and at the same time does not emit RFI/EMI noise that would interfere with other sensitive equipment near the VFD.
- 19.8 The VFD shall include as a minimum a 5% dual DC link or AC line reactor for a clean harmonic signature, which aides in complying with IEEE-519-1992 recommended levels. The VFD manufacturer and representative shall assist in ensuring that the VFD's applied meet IEEE-519-1992 by completing a computer aided Harmonic Analysis of the complete system.

- 19.9 The VFD shall include as a standard a built-in digital keypad/display panel. This panel shall provide "Hand" off "Auto" selection, and a manual speed adjustment via up and down arrows. All faults and warnings shall be provided in "Plain English" for operation without a manual. The drive shall have a complete manual stored in memory that can be accessed with a single keystroke. This display shall be password protected and allow all setup parameters to be adjusted only by authorized personnel.
- 19.10 The VFD shall include built in Startup, Diagnostic, and Maintenance assistants, which allow for step-by-step startup procedures, troubleshooting, and the ability to indicate when the VFD and the system it is applied to needs preventive maintenance performed.
- 19.11 The VFD shall include a real time clock with a day/date stamp for troubleshooting purposes. In addition, with the use of this clock the drive shall be capable of stand-alone operation and act as a unitary controller.
- 19.12 The VFD shall include (2) Analog inputs either 4–20 mdc or 0-10 vdc, (6) programmable Digital Inputs, (2) Programmable analog Outputs, (3) Form C Relay output rated 2 amps continuous minimum, and (2) PID Process controllers.
- 19.13 The VFD keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (LED and alpha-numeric codes are not acceptable). All VFD faults shall be displayed in English words.
- 19.14 BYPASS – As scheduled on the drawings, the drive shall be provided with an integral Bypass circuit which includes a pair of 115V electrically interlocked contactors for drive and bypass operation. The drive shall include a main input circuit breaker, drive input service/isolation switch, and motor overload protection adjustable for either Class 10, 20 or 30 operation. The bypass shall include a built-in status display which shows via colored LED's the system operational status including safeties and run permissive for ease of operation. The Bypass shall have its own interactive, programmable keypad. The Bypass shall provide single-phase protection for the motor while operating in bypass. Bypass that does not protect the motor from single-phase operation shall not be acceptable.
- 19.15 The drive and bypass system shall have embedded serial communication capabilities that allow direct connection to Modbus, Johnson Controls, Siemens and BACnet automation systems as part of the drives software suite without the need for extra hardware cards or gateways. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). In addition, the drive shall be capable of interfacing with Lonworks with the addition of a communication module.
- 19.16 All VFDs shall be provided and installed in strict accordance with the manufacturer's recommendations.

**PART 20 – GEOTHERMAL HEAT PUMP WATER LOOP CONTROL:**

- 20.1 The Geothermal Heat Pump Water Loop System consists of circulating pumps (P-1A/P-1B) and associated pump VFD's.

- 20.2 HEAT PUMP LOOP WATER DISTRIBUTION: The heat pump water distribution is accomplished by pumps P-1A/P-1B. One pump is required to satisfy the building load for each set of pumps; the other pump is for reserve. The pumps shall be set-up for automatic lead/lag operation. The pumps are to be variable flow and a variable speed pump controller unit (VFD) is provided by the TCC contractor to control the speed of the pumps.
- 20.3 One differential pressure is located on the drawings to measure water differential pressure for each set of pumps. This contractor shall provide all control wiring necessary for proper system operation. The differential pressure sensor shall be monitored by the unitary controller for the distribution pumps.
- 20.4 The differential pressure shall be set at 10.0 p.s.i. (adj.). If the pump controller senses that the differential pressure is below the pressure setpoint, the speed of the lead pump shall increase. If the pump controller senses that the differential pressure is above the pressure setpoint, the speed of the lead pump shall decrease.
- 20.5 Install temperature sensors on the supply and return of the geothermal loop to the building to be trended at the BAS.
- 20.6 Side Filtration – Only allow side filtration pump to run when the geothermal pump(s) is running. For the first year of operation, schedule the filtration pump to run from 8am-12pm (4 hours daily – adjustable). After the first year, schedule to be coordinated with owner.

**PART 21 - OUTSIDE AIR SYSTEMS (OA-1, OA-2):**

- 21.1 There are two outside air systems in this facility.
- 21.2 Each system shall operate under the control of a local, stand-alone, microprocessor based DDC controller.
- 21.3 Each system shall be placed into the occupied/unoccupied mode based upon the user adjustable schedule at the Global Control Panel. These systems shall be in the occupied mode during regular building hours only.
- 21.4 If communication is lost between the Global Control Panel and the Outside Air System Controller, then the Outside Air System shall be placed into the unoccupied mode until communication is restored.
- 21.5 Each system will be placed into a Mode of Operation based upon the following adjustable temperature schedule:

<u>Outside Air Temperature</u>	<u>Mode of Operation</u>
65 deg F or greater (adj.)	Cooling Mode
Between 55 deg F and 65 deg F (adj.)	Economizer Mode
55 deg F or less (adj.)	Heating Mode

- 21.6 In the unoccupied mode and morning warm up mode:
- The supply fan and exhaust shall be off,
  - The energy recovery wheel shall be off,

- The outside air damper and exhaust air damper shall be fully closed
- 21.7 When placed into the occupied mode, the following shall occur:
- The energy recovery wheel shall start and operation shall be proved via current switch,
  - The outside air damper and exhaust air damper shall fully open and be proved via damper end switch, attached to damper blades.
  - The supply fan and exhaust fan shall start and operation shall be proved via damper end switches.
  - The system shall not start if any one component does not prove operation.
- 21.8 In the occupied mode, the unit shall maintain a discharge air temperature (adj.) based upon the following schedule:
- | <u>Discharge Air Temperature</u> | <u>Mode of Operation</u> |
|----------------------------------|--------------------------|
| 68 deg F (adj.)                  | Cooling Mode             |
| 68 deg F (adj.)                  | Economizer Mode          |
| 72 deg F (adj.)                  | Heating Mode             |
- 21.9 The above discharge temperature control shall be maintained through the operation of the DX compressor(s), SCR electric heat and hot gas reheat.
- 21.10 A smoke detector shall be located in the exhaust air stream of all units. If smoke is detected, then the system shall shutoff and an audio/visual alarm shall activate. Upon correction of the problem, the system shall be reset and shall return to normal operation. Coordinate with Fire Alarm System.
- 21.11 During morning warm up mode, these systems shall be off.
- 21.12 Dehumidification Mode: If the building relative humidity measured at the building exhaust air is 60% (adj.) or higher, the unit shall cycle the compressors to full cooling and utilize the integral hot gas reheat to maintain the discharge air temperature per the mode of operation noted above.

**PART 22 - GEOTHERMAL HEAT PUMPS SEQUENCE OF OPERATION:**

- 22.1 All heat pumps shall operate under (field mounted) control of a local, stand-alone, microprocessor based DDC controller field installed in the unit.
- 22.2 Each unit shall be placed into the occupied/unoccupied mode based upon the building's Global Time Schedule.
- 22.3 If communication is lost between the Global Time Schedule and the Heat Pump Controller, then the Heat Pump Controller shall be placed into the occupied mode until communication is restored.
- 22.4 A smoke detector shall be located in the return air stream of units greater than 2,000 cfm (5 tons or larger) and other units indicated on the floor plans. If smoke is detected, then the system shall shutoff and an audio/visual alarm shall activate. Upon correction of the

problem, the system shall be reset and shall return to normal operation. Coordinate with Fire Alarm System.

- 22.5 During the unoccupied mode, the heat pump shall not operate unless the space temperature falls outside unoccupied setpoints.
- 22.6 During the occupied mode, the fan and compressor(s) shall stage and cycle as required to satisfy space thermostat/sensor setpoint. Whenever heating or cooling is required, the unit's three-wire, two-way, two-position control valve shall open and prove prior to compressor operation. For units 2 tons and greater, the fan and compressor shall each stage between off, low and high speeds as required to maintain setpoint. The unit shall automatically changeover from heating to cooling. When space temperature is satisfied the fan and compressor shall be off and the control valve shall be closed. To prevent short cycling a minimum of 5-minute delay when transitioning between heat and cool modes. Current sensor to monitor fan status.
- 22.7 The majority of heat pumps operate with a wall mounted thermostat. The space temperature shall be set per the following modes. Winter – Dead band shall be 69°F - 73°F, Summer - 73°F - 77°F. All unit setpoints and adjustable ranges shall be adjustable through the front end.

**PART 23 – ELECTRIC HEATERS AND BASEBOARD HEATERS:**

- 23.1 EH-1, EH-2, EH-3, BH-4, BH-10: Unit to be provided with an integral thermostat, control the space temperature to 65°F (adj.). TCC to provide a relay to disable the heater when outdoor air temperature is above 40°F (adj.). Indicate heater status and space temperature at the BAS.

**PART 24 – SPLIT-SYSTEM UNITS (AC-1&2/CU-1):**

- 24.2 Provide all necessary wiring, conduit, etc. as required to interlock the controller, indoor air handling unit, and outdoor condensing unit as required to maintain space setpoint. Outdoor condensing unit shall be interlocked so that it is unable to operate when indoor fan is not running.
- 24.3 Provide DDC room temperature sensor and all required interlock wiring. Unit to be on emergency power.
- 24.4 Indicate space temperature at the BAS.

**PART 25 – IDF ROOM (CEF-1):**

- 25.1 The exhaust fan shall operate with a standalone temperature sensor. Install the temperature sensor on the wall.
- Set temperature at 80°F (adj.). The fan shall cycle on the maintain space setpoint. Indicate fan status and room temperature at the BAS.

**PART 26 – GEOTHERMAL FLOW METER ALARM AND EMERGENCY SHUTDOWN FOR MAKE-UP WATER:**

- 26.1 On the makeup water line, a two-way, two-position, normally open valve shall close if (after a time delay of 2 minutes) the makeup water continues flowing at a rate of 3 gallons per minute while the system switch is in the normal operating position. An alarm shall be sent to through the DDC system. An audible alarm mounted on the control panel (mounted very near the makeup network) shall sound and an indicator light will provide visual indication of a problem. A momentary push button on the panel shall be used to silence/acknowledge the alarm and reset system for normal operation after any necessary repairs are made. A switch mounted on the panel shall be used to shut down the alarm while normal system fill operations are performed. This switch and all panel mounted devices are to be appropriately labeled. Provide and coordinate installation by mechanical contractor the valve and ONICON Model F-1310 Inline Turbine Flow meter. Flow meter to be 1 inch union body, scaled 0-10 GPM range is 0-10 volt output.

**PART 27 - THE ELECTRICAL SWITCHGEAR/POWER INTERFACE:**

- 27.1 The electrical switchgear shall be monitored through the DDC system via Modbus communication protocol.

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show Graphic On
Current Phase A					x			x		x
Current Phase B					x			x		x
Current Phase C					x			x		x
Current Neutral					x			x		x
Voltage A-B					x			x		x
Voltage B-C					x			x		x
Voltage C-A					x			x		x
Voltage A-N					x			x		x
Voltage B-N					x			x		x
Voltage C-N					x			x		x
Real Power - kW					x			x		x
Apparent Power - kVA					x			x		x
Power Factor					x			x		x
Frequency					x			x		x
Real Energy - kWh					x			x		x

**PART 28 – EMERGENCY GENERATOR:**

- 28.1 The generator shall be provided with a Modbus Interface. Verify communication protocol with equipment manufacturer.
- 28.2 Provide BAS interface for generator controller and integration into the campus building automation system.
- 28.3 Integration shall allow the BAS to remotely start/stop and change the test schedule of the generator.
- 28.4 Provide gas meter and monitor gas consumption from the emergency generator at the BAS.

**PART 29 – LIGHTING CONTROLS SYSTEMS:**

- 29.1 The TCC will be responsible for dry contact inputs into lighting control interface devices.
- 29.2 The TCC shall map the control of the lighting circuits to the BAS.
- 29.3 The building control panel will provide ON-OFF-AUTO control for the 6 lighting zones – Levels 1-5, and Level 0 in Commons Area.
  - Zone Override ON-override ON
  - Zone Override OFF- override OFF
  - AUTO-The lights will run when called for by building occupancy schedule
  - Building Master Override On-override On
  - Building Master Override Off-override Off
- 29.4 The building control panel will provide ON-OFF-AUTO control for the exterior lighting zone –
  - ON-override ON
  - OFF- override OFF
  - AUTO-The lights will run when called for by the Photocell.
- 29.5 Provide a full graphic page of the building and site lighting zones, indicating the different zones that can be scheduled. A graphic “light bulb” located in the specific area shall indicate whether lights are on or off. Each zone shall be independently scheduled.

**PART 30 – DOMESTIC WATER HEATERS:**

- 30.1 The Contractor shall provide a boiler emergency shutoff button located at the mechanical room exit in accordance with the provisions of the ASME Boiler and pressure Vessel Code, Section IV, Article HG-634. Provide with cover and label Water Heater Emergency Shutdown. The activation of this switch shall shut down the gas trains to each boiler module. The push button shall be the red mushroom type to avoid any confusion with light switches. Each water heater or boiler shall have a dedicated set of contacts on the switch.
- 30.2 The DDC System shall enable/disable the domestic hot water building recirculating pump (DP-1).
- 30.3 The DDC System shall monitor domestic hot water supply temperature at each heater.

**PART 31 - DOMESTIC WATER BOOSTER PUMP**

31.1 The DDC System shall monitor BP-1 status, domestic hot water inlet and outlet pressure.

**PART 32 – VARIABLE FREQUENCY DRIVES (VFD’S):**

32.1 VFD shall include a communications port for LonWorks or BacNet compatible protocol. Coordinate with TCC. Start-stop, status for chiller and control signal shall be hardwired. Provide input points for two preset speeds. Provide two programmable Form C relays rated 2 amps to activate At Speed for pump applications.

32.2 Current VFD status and operating conditions shall be monitored through its communications interface port. The following points shall be monitored and trended through the VFD interface as follows:

	Hardware Points				Software Points					
Point Name	AI	AO	BI	BO	AV	BV	Sched	Trend	Alarm	Show On Graphic
Motor Speed RPM					×			×		×
Motor Frequency Hertz					×			×		×
Motor Current Amps					×			×		×
Motor Runtime					×					×
VFD Status						×		×		×
In Fault Condition						×		×	×	×
In Bypass						×		×	×	×
<b>Totals</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>3</b>	<b>0</b>	<b>6</b>	<b>2</b>	<b>7</b>

**Total Hardware ( 0 )**

**Total Software ( 15 )**

**PART 33 – SUMP PUMP**

33.1 The DDC System shall monitor elevator drainage status and alarm.

**PART 34 – UTILITY CONSUMPTION METERS (REFER TO ELECTRICAL SPECIFICATIONS):**

34.1 All new building projects shall include consumption meters for all incoming utilizes serving that particular building. All meters shall be IP addressable and shall be connected via TC/IP to the central campus BMS system at the Central Plant Coordinate with the NKU project manager on any direct connection/integration desired with the Intelligent Building System. Coordinate level of expectation and acceptable quality/brands of meters with NKU project manager.

**END OF SECTION**

HEAT PUMP WATER LOOP POINT LIST											
	BINARY			ANALOG			FUNCTION				
	STATUS	ALARM	MAINT	POINT	HIGH ALARM	LOW ALARM	START / STOP	LOW LIMIT	RESET	DAY/ NIGHT	SUMME R/WINTE R
Geothermal Supply Temp.	X			X	X	X					
Geothermal Return Temp.	X			X	X	X					
Geothermal Pump P-1A/1B	X						X				
Geothermal Pump P-1A/1B-VFD Speed	X						X				
Geothermal Loop Make-up Water Flow Meter	X			X							
Geothermal Loop Make-up water Control Valve	X			X							
		X		X							
		X					X				
END OF HEAT PUMP WATER LOOP POINTS LIST											

HEAT PUMP POINT LIST											
	BINARY			ANALOG			FUNCTION				
	STATUS	ALARM	MAINT	POINT	HIGH ALARM	LOW ALARM	START/ STOP	LOW LIMIT	RESET	DAY/ NIGHT	SUMME R/WINT ER
Compressor (s)	X		X				X		X		
Supply Fan	X						X		X		
Reversing Valve	X										
Control Valve	X						X				
Zone Temperature				X					X		
Discharge Air Temperature				X							
Supply Fan (DP Sensor)	X			X							
Smoke Detectors (where required)											
END OF HEAT PUMP PRIMARY LOOP POINT LIST											

OUTSIDE AIR/EXHAUST AIR SYSTEMS POINT LIST (OA-1, OA-2)											
	BINARY			ANALOG			FUNCTION				
	STATUS	ALARM	MAINT	POINT	HIGH ALARM	LOW ALARM	START/ STOP	LOW LIMIT	RESET	DAY/ NIGHT	SUMME R/WINT ER
Supply Fan	X	S					X				
Exhaust Fan	X	S					X				
Energy Recovery Wheel (E.R.W.)	X	S					X				
Outside Air Damper	X										
Exhaust Air Damper	X										
Outside Air Temp. Upstream of E.R.W.				X							
Outside Air Temp. Downstream of E.R.W.				X	S	S					
Exhaust Air Temp. Upstream of E.R.W.				X							
Unit Discharge Air Temp.				X	S	S					
DX Compressor	X	X		X			X				
Electrical Heat	X			X			X				
Wheel Freeze up		X									
END OF OUTSIDE AIR/EXHAUST AIR SYSTEMS POINT LIST											

S= Software Point  
X= Hardware Point  
**END OF SECTION**

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## **SECTION 26 05 00**

### **GENERAL REQUIREMENTS FOR ELECTRICAL**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED REQUIREMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 01 and 26 Specification Sections, apply to this Section.
- B. The Instructions to Bidders, General and Special Conditions, and all other contract documents shall apply to the Contractor's work as well as to each of his Sub Contractor's work. Each Contractor is directed to familiarize himself in detail with all documents pertinent to this Contract. In case of conflict between these General Provisions and the General and/or Special Conditions, the affected Contractor shall contact the Engineer for clarification and final determination.
- C. Each Contractor shall be governed by any alternates, unit prices and Addenda or other contract documents insofar as they may affect his part of the work.

##### **1.2 SUMMARY**

- A. The work included in this division consists of the furnishing of all labor, equipment, transportation, supplies, material and appurtenances and performing all operations necessary for the satisfactory installation of complete and operating Electrical Systems indicated on the drawings and/or specified herein.
- B. Any materials, labor, equipment or services not mentioned specifically herein which may be necessary to complete or perfect any part of the Electrical Systems in a substantial manner, in compliance with the requirements stated, implied, or intended in the drawings and specifications, shall be included as part of this Contract. The Contractor shall give written notice of any materials or apparatus believed inadequate or unsuitable; in violation of laws, ordinances, rules or regulations of authorities having jurisdiction; and any necessary items of work omitted a minimum of ten days prior to bid. In the absence of such written notice and by the act of submitting his bid, it shall be understood that the Contractor has included the cost of all required items in his bid, and that he will be responsible for the approved satisfactory functioning of the entire system without extra compensations.
- C. It is not the intent of this section of the specifications (or the remainder of the contract documents) to make any specific Contractor, other than the Contractor holding the prime contract, responsible to the Owner, Architect and Engineer. All transactions such as submittal of shop drawings, claims for extra costs, requests for equipment or

materials substitution, shall be done through the Contractor to the Architect (if applicable), then to the Engineer.

- D. This section of the Specifications or the arrangement of the Contract Documents shall not be construed as an attempt to arbitrarily assign responsibility for work, material, equipment or services to a particular trade Contractor or Sub-Contractor. Unless stated otherwise, the subdivision and assignment of work under the various sections shall be the responsibility of the Contractor holding the Prime Contract.

### 1.3 DEFINITIONS

- A. Prime Contractor - The Contractor who has been engaged by the Owner in a contractual relationship to accomplish the work.
- B. Contractor - Any Contractor whether bidding, proposing or working independently or under the supervision of a General Contractor, Prime Contractor, Construction Manager and who installs any type of Electrical Work as specified in the Contract Documents.
- C. Electrical Contractor - Any Contractor whether bidding or working independently or under the supervision of a General Contractor, that is: the one holding the Prime Contract and who installs any type of Electrical work, such as: power, lighting, television, telecommunications, data, fiber optic, intercom, fire detection and alarm, security, video, underground or overhead electrical, etc.
- D. Electrical Sub-Contractor - Each or any Contractor contracted to, or employed by, the Electrical Contractor for any work required by the Electrical Contractor.
- E. Engineer - The Consulting Mechanical-Electrical Engineer either consulting to the Owner, Architect, or Other, etc. In this case: CMTA, Inc., Consulting Engineers.
- F. Architect - The Architect of Record for the project.
- G. Contract Documents - All documents pertinent to the quality and quantity of work to be performed on this project. Includes, but not limited to: Plans, Specifications, Instructions to Bidders, General and Special Conditions, Addenda, Alternates, Lists of Materials, Lists of Sub-Contractors, Unit Prices, Shop Drawings, Field Orders, Change Orders, Cost Breakdowns, Schedules of Value, Periodical Payment Requests, Construction Manager's Assignments, Architect's Supplemental Instructions, Construction Contract with Owner, etc.
- H. Bidder/Proposer - Any person, agency or entity submitting a proposal to any person, agency or entity for any part of the work required under this contract.
- I. The Project - All of the work required under this Contract.
- J. Furnish - Deliver to the site in good condition and turn over to the Contractor who is to install.
- K. Provide - Furnish and install complete, tested and ready for operation.
- L. Install - Install equipment furnished by others in complete working order.
- M. Indicated - Listed in the Specifications, shown on the Plans or Addenda thereto.

- N. Basis of Design (BOD): Documentation of primary thought processes and assumptions behind design decisions made to meet design intent. Describes systems, components, conditions and methods chosen to meet intent.
- O. Monitoring: Recording of parameters (flow, current, status, pressure, etc.) of equipment operation using data loggers or trending capabilities of control systems.
- P. Start-up: The activities where systems or equipment are initially tested and operated. Start-up is completed prior to functional testing.
- Q. Vendor: Supplier of equipment.
- R. Typical or Typ- Where indicated repeat this work, method or means each time the same or similar condition occurs whether indicated or not.

#### 1.4 ABBREVIATIONS

- A. ADA - Americans with Disabilities Act.
- B. AHJ – Authority Having Jurisdiction
- C. ANSI - American National Standards Institute.
- D. ASA – American Standards Association.
- E. ASTM – American Society for Testing Materials.
- F. ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers.
- G. BAS – Building Automation System.
- H. BICSI – Building Industry Consulting Services International
- I. CM – Construction Manager
- J. EC – Electrical Contractor
- K. FCC – United States Federal Communications Commission
- L. GC – General Contractor
- M. IECC – International Energy Conservation Code
- N. IEEE – Institute of Electrical and Electronics Engineers.
- O. ISO – International Standards Organization.
- P. NEC – National Electrical Code (NFPA 70).
- Q. NECA – Standards for Installation.
- R. NEMA - National Electrical Manufacturers Association.
- S. NESC – National Electrical Safety Code.
- T. NFPA - National Fire Protection Association.
- U. NRTL: Nationally Recognized Testing Laboratory
- V. OSHA - Office of Safety and Health Administration.
- W. SPD: Surge Protection Device
- X. TIA – Telecommunications Industry Association
- Y. RFI – Request for Information
- Z. RIO – Rough-in Only
- AA. UL - Underwriters Laboratories, Inc.
- BB. UON – Unless otherwise noted.

#### 1.5 REFERENCES

- A. Contractor is responsible for knowledge and application of current versions of all applicable standards and codes. In cases where listed standards and codes have been

updated, Contractor shall adhere to the most recent revisions, including all relevant changes or addenda at the time of installation.

- B. This document does not replace any code, either partially or wholly. The contractor shall conform to local codes and regulations that apply to this project
- C. If there is a conflict between applicable documents, then the more stringent requirement shall apply.
- D. Reference Standards
  - 1. NFPA
    - a. NFPA 70, National Electric Code (NEC)
  - 1. NECA
    - a. NECA 1, "Standard for Good Workmanship in Electrical Construction"
  - 2. IEEE
    - a. C2, National Electrical Safety Code

#### 1.6 DRAWINGS AND SPECIFICATIONS

- A. The drawings are diagrammatic only and indicate the general arrangement of the systems and are to be followed insofar as possible. If deviations from the layouts are necessitated by field conditions, detailed layouts of the proposed departures shall be submitted in writing to the Engineer for approval before proceeding with the work. The Contract Drawings are not intended to show every vertical or horizontal offset which may be necessary to complete the systems. Contractors shall, however, anticipate that additional offsets may be required and submit their bid accordingly.
- B. The drawings and specifications are intended to supplement each other. No Contractor, bidder, proposer or supplier shall take advantage of conflict between them, or between parts of either, but should this condition exist, the Contractor or supplier shall request a clarification of the condition at least ten days prior to the submission of bids so that the condition may be clarified by Addendum. In the event that such a condition arises after work is started, the interpretation of the Engineer shall be the determining factor. In all instances, unless modified in writing and agreed upon by all parties thereto, the Contract to accomplish the work shall be binding on the affected Contractor.
- C. The drawings and specifications shall be considered to be cooperative and complimentary and anything appearing in the specifications which may not be indicated on the drawings or conversely, shall be considered as part of the Contract and must be executed the same as though indicated by both.
- D. This Contractor is responsible for all field measurements and shall be responsible for correct fitting. They shall coordinate this work with all other branches of work in such a manner as to cause a minimum of conflict or delay.
- E. The Engineer shall reserve the right to make minor adjustments in location of conduit, fixtures, outlets, switches, etc., where he considers such adjustments desirable in the interest of concealing work or presenting a better appearance.

- F. Each Contractor shall evaluate ceiling heights called for on Architectural Plans. Where the location of Electrical equipment may interfere with ceiling heights, the Contractor shall call this to the attention of the Engineer in writing prior to making the installation. Any such changes shall be anticipated and requested sufficiently in advance so as to not cause extra work on the part of the Contractor or unduly delay the work.
- G. Should overlap of work between the various trades become evident, this shall be called to the attention of the Engineer. In such an event, neither trade shall assume that he is to be relieved of the work which is specified under his branch until instructions in writing are received from the Engineer.
- H. The Electrical drawings are intended to show the approximate location of equipment, materials, etc. Dimensions given in figures on the drawings shall take precedence over scaled dimensions and all dimensions whether given in figures or scaled shall be verified in the field. In case of conflict between small and large-scale drawings, the larger scale drawings shall take precedence.
- I. The Electrical Contractor and his Sub-Contractors shall review all drawings in detail as they may relate to their work (structural, architectural, site survey, mechanical, etc.). Review all drawings for general coordination of work, responsibilities, ceiling clearances, wall penetration points, chase access, fixture elevations, etc. Provide any pertinent coordination or apparent conflict comments to the Engineers at least ten (10) days prior to bids, for issuance of clarification by written addendum.
- J. Where on any of the drawings a portion of the work is drawn out and the remainder is indicated in outline, or not indicated at all, the parts drawn out shall apply to all other like portions of the work. Where ornament or other detail is indicated by starting only, such detail shall be continued throughout the courses or parts in which it occurs and shall also apply to all other similar parts of the work, unless otherwise indicated.
- K. Special Note: Always check ceiling heights indicated on Drawings and Schedules and insure that these heights may be maintained after all mechanical and electrical equipment is installed. If a conflict is apparent, notify the Engineer in writing for instructions.

#### 1.7 SITE EXAMINATION

- A. Each Contractor shall inform himself of all of the conditions under which the work is to be performed, the site of the work, the structure of the ground, the obstacles that may be encountered, the availability and location of necessary facilities and all relevant matters concerning the work. All Contractors shall carefully examine all Drawings and Specifications and inform themselves of the kind and type of materials to be used throughout the project and which may, in any way, affect the execution of his work.
- B. Each Contractor shall fully acquaint himself with all existing conditions as to ingress and egress, distance of haul from supply points, routes for transportation of materials, facilities and services, availability of temporary or permanent utilities, etc. The Contractor shall include in his work all expenses or disbursements in connection with such matters and conditions. Each Contractor shall verify all work shown on the drawings and conditions at the site and shall report in writing to the Engineer ten (10)

days prior to bid, any apparent omissions or discrepancies in order that clarifications may be issued by written addendum. No allowance is to be made for lack of knowledge concerning such conditions after bids are accepted.

#### 1.8 CODES, PERMITS, AND FEES

- A. The Contractor shall give all necessary notices, obtain and pay for all permits, government sales taxes, fees, and other costs including utility connections or extensions, in connection with his work. As necessary, he shall file all required plans, utility easement requests and drawings, survey information on line locations, load calculations, etc., prepare all documents and obtain all necessary approvals of all utility and governmental departments having jurisdiction; obtain all required certificates of inspection for his work and deliver same to the Engineer before request for acceptance and final payment for the work.
- B. Ignorance of Codes, Rules, regulations, utility company requirements, laws, etc., shall not diminish or absolve Contractor's responsibilities to provide and complete all work in compliance with such.
- C. The Contractor shall include in the work, without extra cost, any labor, materials, services, apparatus or drawings required in order to comply with all applicable laws, ordinances rules and regulations, whether or not shown on drawings and/or specified.
- D. All materials furnished and all work installed shall comply with the current edition of the National Electrical Codes, National Fire Codes of the National Fire Protection Association, the requirements of local utility companies, and with the requirements of all governmental agencies or departments having jurisdiction.
- E. All material and equipment for the electrical systems shall bear the approval label, or shall be listed by the Underwriters' Laboratories, Incorporated. Listings by other testing agencies may be acceptable with written approval by the Engineer.
- F. All electrical work is to be constructed and installed in accordance with plans and specifications which have been approved in their entirety and/or reflect any changes requested by the State Fire Marshal, as applicable or required. Electrical work shall not commence until such plans are in the hands of the Electrical Contractor.
- G. The Contractor shall insure that his work is accomplished in accord with OSHA Standards and any other applicable government requirements.
- H. Where conflict arises between any code and the plans and/or specifications, the code shall apply except in the instance where the plans and specifications exceed the requirements of the code. Any changes required as a result of these conflicts shall be brought to the attention of the Engineer at least ten working days prior to bid date, otherwise the Contractor shall make the required changes at his own expense. The provisions of the codes constitute minimum standards for wiring methods, materials, equipment and construction and compliance therewith will be required for all electrical work, except where the drawings and specifications require better materials,

equipment, and construction than these minimum standards, in which case the drawings and specifications shall be the minimum standards.

#### 1.9 COST BREAKDOWNS AND PAY APPLICATIONS

- A. Within thirty days after acceptance of the Contract, each Contractor is required to furnish to the Engineer one copy of a detailed cost breakdown on each respective area of work. These cost breakdowns shall be made on forms provided or approved by the Engineer or Architect. Payments will not be made until satisfactory cost breakdowns are submitted. Refer to Division 0 and 1 specification sections for additional requirements.
- B. In addition to cost breakdowns by specification section, the following shall also be provided: Material and labor shall be listed separately. These items are in addition to items listed in front-end specifications. Pay special attention to required withholding percentages for startup, testing, documentation, acceptance, owner training, etc. The breakdown shall be minimally as follows:
  - 1. Permitting
  - 2. Mobilization
  - 3. Electrical Shop Drawings/Submittals
  - 4. Electrical Coordination Drawings
  - 5. Temporary Power
  - 6. Owner Training & Acceptance
  - 7. Punchlist
  - 8. As-Built/Record Drawings & Acceptance
  - 9. O&M Manuals & Acceptance
  - 10. Warranty
  - 11. Demobilization
  - 12. Fire Alarm System Startup, Testing, & Verification (shall equal 5% of Equipment Value)
  - 13. Electrical Distribution Equipment Startup, Testing, & Verification (shall equal 2.5% of Equipment Value)
  - 14. Lighting and Lighting Controls Startup, Testing, & Verification (shall equal 2.5% of Equipment Value)
  - 15. Low Voltage Systems Startup, Testing, & Verification (shall equal 5% of Equipment Value)
  - 16. Emergency Engine Generator Standby Systems Startup, Testing, & Verification (shall equal 2.5% of Equipment Value)

#### 1.10 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
  - 1. The Contractor is expressly directed to read the General Conditions and all detailed sections of these specifications for all other trades and to study all drawings applicable to his work, including Architectural, Mechanical, Structural and other pertinent Drawings, to the end that complete coordination between trades will be affected.

2. Refer to Coordination Among Trades, Systems Interfacing and Connection of Equipment Furnished by Others section of these Specifications for further coordination requirements. The Contractor is responsible for the correct location of all rough-in and connections at every piece of equipment. Work not correctly located shall be relocated at the Contractor's expense.
3. Where any work is to be installed in close proximity to, or will interfere with work of other trades, each shall cooperate in working out space conditions to make a satisfactory adjustment. If so, directed by the Engineer, the Contractor shall prepare composite working drawings and sections at a suitable scale not less than  $\frac{1}{4}" = 1'-0"$ , clearly indicating how his work is to be installed in relation to the work of other trades, or so as not to cause any interference with work of other trades. He shall make the necessary changes in his work to correct the condition without extra charge.
4. The Contractor shall furnish to other trades, as required, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

#### 1.11 ACTION SUBMITTALS

- A. Prior to the start of work the contractor shall submit the following. Work shall not proceed without the Engineer's and Owner's approval of the submitted items.
- B. Product Data: For each type of product specified.
  1. Include manufacturer's data sheets indicating construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment and components.
  2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
  3. Format and Organization: Electronic PDF submittal organized in the following order
    - a. Cover: clearly display the following information: Owner name, Project name, Submittal name, project submittal number, Contractor name and contact information, applicable specification section numbers.
    - b. Table of Contents: Include a TOC that lists materials by section number, with a brief product description, manufacturer and part number, and list the submittal page number per product
    - c. Product Information
  4. Clearly and precisely indicate the submitted product and accessories by part number using an electronic annotation (arrow, rectangle, oval, etc.).
- C. Equipment Shop Drawings: For custom enclosures, cabinets, manholes, signal reference grid, etc. Include plans, elevations, sections, and attachment details.
  1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

D. Coordination Drawings:

1. Detailed electronic coordination drawings shall be required for this project. A specific line-item shall be included on the schedule of values by each Trade for "preparation of coordination drawings". This line-item value shall be approved by the Engineer. The Engineer and the Engineer's Field Inspector shall closely monitor progress and quality of the preparation of the electronic coordination drawings and may withhold pay requests as deemed appropriate.
2. Coordination Drawings shall be provided on this project by each Trade (Mechanical, Fire Protection, Electrical). Drawings shall be 30x42 sheet size and shall be at 1/4" scale and shall match the drawing setup as included in the Architectural Drawings. Drawings shall be prepared in electronic format utilizing AutoCad software. The Architect and Engineer will supply electronic drawings files of the Contract Documents upon the Contractor's request and release.
3. The basis for the Coordination Drawings shall be the sheet metal ductwork fabrication shop drawings, all electrical feeder conduits and other conduits 1" and larger, and beverage conduit system piping and components in ceiling spaces. The Coordination Drawings shall be prepared by the Mechanical Contractor. The Coordination Drawings shall indicate (1) systems above ceilings in finished areas, (2) systems supported from the structure in finished areas without ceilings, (3) systems in the mechanical rooms, and (4) all wall, roof, floor penetrations. These drawings shall indicate all ductwork as double lined with bottom elevations noted (5) all under slab conduit and piping.
4. The sheet metal fabrication shop drawings shall be completed in a timely manner so as not to conflict with construction schedule and phasing plan. At the Construction Manager's discretion, these drawings shall be completed in phases to correspond with the project construction work sequencing. The Mechanical Contractor shall furnish an electronic copy of these ductwork shop drawings to all other Trades, specifically the Fire Protection and Electrical and other Contractors as requested by the Construction Manager for the purpose of including other trades work on the Coordination Drawings.
5. Pre-Coordination Meetings with all necessary trades shall occur. During these meetings, the Contractors shall discuss locations/elevations where piping, conduits, cable path, etc. will be installed with respect to the sheet metal fabrication drawings and other trades. The sheet metal ductwork and gravity piping systems shall be given the first priority. Within 30 days of the meeting, each Trade shall provide the Mechanical Contractor electronic drawings of all of their systems (with elevation noted), coordinated with the ductwork and other trades for them to incorporate into the Coordination Drawings. Coordination Meetings shall then occur so that all conflicts can be resolved between Trades. All conflicts shall be resolved between all Trades at these Coordination Meetings and the Mechanical Contractor shall then amend the Drawings to include the Final Coordinated Work.
6. It is realized that not all systems can be completely detailed. The coordination drawings shall include the following at a minimum:
  - a. All supply/return/exhaust ductwork.
  - b. All above slab sanitary and roof drainage piping.
  - c. HVAC, fire protection and domestic water piping which are 2" in size and greater, excluding insulation.
  - d. Electrical conduits which are 1" in size and greater.

- e. J-hook and cable tray cabling paths
  - f. Multiple smaller piping/conduits hung on a common hanger.
  - g. All wall, roof, floor penetrations.
  - h. Light fixtures.
7. After completion of the Final Coordination Drawings, a Final Review with the all Trades shall occur to provide any final comments and approval by all Trades. Other interim coordination meeting will be required to ensure successful coordination drawings. Any additional coordination items will be updated by the Mechanical Contractor. The Final Approved Coordination Drawings shall be distributed electronically (on CD) to each Trade by the Mechanical Contractor. The Mechanical Contractor shall also furnish a complete 30x42 paper set of drawings to the jobsite main office and shall utilize them for updates of field conditions/deviations that occur during construction. Final Approved Coordination Drawings shall also be distributed to the Construction Manager, Owner, Architect and Engineer for their Records. This process shall be completed prior to starting any work.
8. Each Contractor shall ensure that any deviations from the Coordination Drawings are recorded as they occur, in red erasable pencil on record drawings kept at the jobsite. Upon completion of a particular phase, the Mechanical Contractor shall incorporate all field deviations into the Coordination Drawings to be utilized as Record Drawings. The Engineer shall review the Record Documents from time to time to ensure compliance with this specification. Compliance shall be a contingency of final payment. Also, pay particular attention to Deviations in the Control Systems and all exterior utilities. Keep information in a set of drawings set aside at the job site especially for this purpose. The Record Drawings shall be distributed electronically (on CD) to the Construction Manager, Owner, Architect and Engineer for their Records.
9. The Mechanical Contractor is responsible to the General Contractor for the shop drawing layout of the following rooms and details:
- a. Concrete pads and foundations
  - b. Equipment room layouts with actual equipment
  - c. Roof layouts
  - d. Trench locations and sizes
  - e. Dimensioned floor drain locations
  - f. Congested areas above ceilings adjacent to mechanical and electrical rooms
  - g. Dimensioned ductwork shop drawings
10. The Electrical Contractor is responsible to the General Contractor for the shop drawing layout of the following rooms and details:
- a. Concrete pads and foundations
  - b. Equipment room layouts with actual equipment
  - c. Routes of feeder conduits and all other conduits 1.5" and larger, floors 2 through 5 and roof
  - d. J-hook and cable tray cabling paths
  - e. Trench locations and sizes
  - f. Congested areas above ceilings adjacent to mechanical and electrical rooms
  - g. Refer to Part 41 for additional requirements.
  - h. Light fixture locations
  - i. Exact layouts of all work in open ceiling areas

1.12 INFORMATIONAL SUBMITTALS

- A. Qualification Data for Manufacturer, Contractor, Project RCDD, Project Manager, Lead Technician, and Installers.
- B. Sample Warranties
- C. Sample Field Quality Control Reports
- D. Twisted pair and Optical Fiber Cable Testing Plans:
  - 1. Sample test report sheet for each type of test required
  - 2. Description of the cable testing procedures to be used including equipment to be used and testing standards equipment will test to.

1.13 CLOSEOUT SUBMITTALS

- A. All items listed in this section shall be provided to the engineer upon substantial completion. Provide three bound copies with complete index and tabs to locate each item.
- B. As-Built Drawings: Plans showing as-built locations that fully represent actual installed conditions and that incorporate modifications made during the course of construction. The Contractor shall insure that any deviations from the design are being recorded daily, as necessary, on record drawings being maintained by the Contractor. Dimensions from fixed, visible permanent lines or landmarks shown in vertical and horizontal ways shall be utilized. Compliance shall be a requirement for final payment. Pay particular attention to the location of underfloor or underground exterior in-contract or utility-owned or leased service lines, main switches and other appurtenances important to the maintenance and safety of the Electrical System. Deliver these record drawings to the Engineer as a system is completed, within ten days of the mark-up and/or while the accuracy of the mark-ups can be verified visually. Monthly payment may be withheld if the requirement is not complied with.
- C. Start-up and System Testing Certifications and Reports: Provide reports from all required testing to indicate procedures followed and complete results of all tests. Provide reports on manufacturer's standard forms for all equipment and system tests. Testing shall be per applicable NEC, NFPA, UL, NETA, and/or ANSI standards.
- D. Operation and Maintenance Data:
  - 1. For all equipment, provide detailed operating instructions
  - 2. Each contractor shall furnish three complete bound sets for approval to the Engineer of typewritten and/or blueprinted instructions for operating and maintaining all systems and equipment included in this contract. All instructions shall be submitted in draft, for approval, prior to final issue. Manufacturer's advertising literature or catalogs will not be acceptable for operating and maintenance instructions.
  - 3. Each Contractor, in the above-mentioned instructions, shall include the maintenance schedule for the principal items of equipment furnished under this

- contract and a detailed, easy to read parts list and the name and address of the nearest source of supply.
4. Provide detailed maintenance instructions, including recommended preventative maintenance schedules for all equipment requiring maintenance. For lighting and lighting controls, provide recommended relamping program, provide a schedule for inspecting and recalibrating lighting controls, and provide a recommended settings list for all components with adjustable settings.
  5. Provide contacts (company name, address, phone number, email) where parts may be purchased for all equipment.
  6. Shop drawings WILL NOT be accepted as satisfying the requirement for Operation and Maintenance Manuals.
- E. Shop Drawings: Provide complete copies of all approved shop drawings. Where shop drawings were returned "Furnish as Corrected", the contractor shall make the corrections noted by the engineer and submit final corrected shop drawings with close-out documentation. Product and System Warranty Documentation from both manufacturer and contractor.
- F. Parts Lists: Provide an inventory of all spare parts, special tools, attic stock, etc. that have been provided to the owner.
- G. Warranties: Contractor's one-year warranty and all other specific warranties indicated in the construction documents.
- H. Training Verification: Provide certification that all specified training has been completed. List training session dates, times, and types.
- I. Inspection Certificates: Provide certificates of inspection from electrical inspector, fire marshal, and any other required special inspections.
- J. Panel Schedules: Provide hard copies and digital copies of Excel files for all panel-board schedules.
- K. Final Power System Study Reports.
- L. Fire Alarm System Certification.
- M. Lightning Protection System Certification.
- N. Power Riser Diagram: Provide a framed full-size copy of the overall power riser diagram (under glass) to the Owner. Also, provide three (3) vinyl-coated copies of same. Where an existing power riser diagram is present, the Contractor shall obtain the document from the Owner, and update in digital format with the scope of this project. Edits shall be in digital format and this work shall be closely coordinated with the Owner.
- O. Fire Alarm Riser Diagram: Provide vinyl coated fire alarm system diagrams including floor plans and device addresses at fire alarm equipment. Provide a full system diagram at the main fire alarm control panel and provide the respective level's system diagram at the NAC panels located on other levels of the structure. Where an existing

power riser diagram is present, the Contractor shall obtain the document from the Owner, and update in digital format with the scope of this project. Edits shall be in digital format and this work shall be closely coordinated with the Owner.

#### 1.14 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories shall be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Manufacturer Qualifications
  - 1. Five continuous years, minimum, design and manufacture of the materials and equipment specified herein.
  - 2. Manufacturer(s) of products and equipment specified herein shall demonstrate that they have a quality assurance program in place to assure that the specifications are met. Including at a minimum:
    - a. Incoming inspection of raw materials
    - b. In-process inspection and final inspection of the cable product
    - c. Calibration procedures of test equipment to be used in the qualifications of the product
    - d. Recall procedures in the event that out of calibration equipment is identified.
  - 3. Conform to government standards on quality assurance for applications within these specifications.
- C. Contractor Qualifications: Provide documentation of the following qualifications:
  - 1. Be in business a minimum of 5 continuous years
  - 2. Contractor shall demonstrate satisfaction of sound financial condition and can be adequately bonded and insured.
  - 3. Possess those licenses/permits required to perform telecommunications installations in the specified jurisdiction.
  - 4. Personnel knowledgeable in local, state, province and national codes, and regulations. All work shall comply with the latest revision of the codes or regulations. When conflict exists between local or national codes or regulations, the most stringent codes or regulations shall be followed.
  - 5. Must possess current liability insurance certificates.
  - 6. Must have personnel fluent in the use of Computer Aided Design and possess and operate CAD software using .DWG format.
  - 7. All Sub-Contractors bidding the electrical work must have completed one project of 70% this subcontract cost size and two projects of 50% this subcontract size.
- D. Project Personnel Requirements:
  - 1. Each Contractor and Sub-Contractor shall personally supervise the work or have a competent superintendent on the project site at all times when work of this section is performed.

2. All electrical work shall be accomplished by qualified workmen competent in the area of work for which they are responsible. Untrained and incompetent workmen as evidenced by their workmanship shall be relieved of their responsibilities in those areas. The Engineer shall reserve the right to determine the quality of workmanship of any workman and unqualified or incompetent workmen shall refrain from work in areas not satisfactory to him. Requests for relief of a workman shall be made through the normal channels of responsibility established by the Architect or the contract document provisions.
  3. All electrical work shall be accomplished by Journeymen electricians under the direct supervision of a licensed Electrician. All applicable codes, utility company regulations, laws and permitting authority of the locality shall be fully complied with by the Contractor.
  4. Special electrical systems, such as Fire Detection and Alarm Systems, Telecommunications or Data Systems, Video Systems, Special Electronic Systems, Control Systems, etc., shall be installed by workmen normally engaged or employed in these respective trades.
  5. The Contractor shall be responsible for the conduct of all workmen under his supervision. Misconduct on the part of any workmen to the extent of creating a safety hazard, or endangering the lives and property of others, shall result in the prompt relief of that workman. The consumption or influence of alcoholic beverages, narcotics or illegally used controlled substances on the jobsite is strictly forbidden.
- E. References: The Customer may, with full cooperation of The Contractor, visit client installations to observe equipment operations and consult with references. Specified visits and discussion shall be arranged through The Contractor; however, The Contractor personnel shall not be present during discussions with references. The Contractor must provide a minimum of three (3) reference accounts at which similar work, both in scope and design, have been completed by The Contractor within the last two (2) years.

#### 1.15 DELIVERY, STORAGE, AND HANDLING

- A. Environmental Limitations: Do not deliver or install equipment, cables, and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
- B. Visually inspect cables upon receipt at Project site. If damage is suspected, test cables to verify and validate the manufacturer's factory testing certifications.
  1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
  2. Test each pair of UTP cable for open and short circuits.
- C. Comply with manufacturer's storage and handling requirements for each product.
- D. Maintain factory wrapping or provide a heavy canvas/plastic cover to protect units from dirt, water, construction debris, and traffic.

- E. Do not install damaged materials and equipment.
- F. Visibly damaged products shall be returned to the supplier and replaced at no additional cost to the Owner.

#### 1.16 GENERAL PRODUCT WARRANTY

- A. General Requirements: Comply with additional requirements in contract general requirements and extended warranties required in other specification sections. Refer to all other Division 26 sections for specific additional warranty requirements that exceed or are in addition to those of this section.
- B. Contractor shall provide all services, materials, and equipment necessary for successful operation of entire electrical. Scope of warranty includes all equipment, devices, wiring, accessories, software, hardware, installation, programming, and configuration required to maintain a complete and operable system. Provide manufacturer's published recommended preventative maintenance procedures during warranty period. This shall apply to all items except those specifically excluded, or items wherein a longer period of service and warranty is specified or indicated. All warranties shall be effective for one year, minimum, from date Certificate of Final Acceptance is issued. Use of systems provided under this section for temporary services and facilities shall not constitute final acceptance of work nor beneficial use by Owner and shall not institute warranty period. The warranty shall cover repair or replacement of defective materials, equipment, workmanship, and installation that may be incurred during this period. Warranty work is to be done promptly and to Owner's satisfaction. In addition, warranty shall cover correction of damage caused in making necessary repairs and replacements under warranty. Additional warranty responsibilities are:
  - 1. Obtain written equipment and material warranties offered in manufacturer's published data without exclusion or limitation, in Owner's designated name. Replace material and equipment that require excessive service during guarantee period as determined by Owner.
  - 2. Provide 2-business day service beginning on date of Substantial Completion and lasting until termination of warranty period. Service shall be at no cost to Owner. Service can be provided by installing contractor or by a separate service organization. Choice of service organization shall be subject to Owner's approval. Submit name and a phone number that will be answered on a 24-hour basis each day of week, for duration of service.
  - 3. Submit copies of equipment and material warranties to Owner before final acceptance.
  - 4. At end of warranty period, transfer manufacturers' equipment and material warranties still in force to Owner, at no additional costs to the Owner.
  - 5. If warranty work problems cannot be corrected immediately to Owner's satisfaction, advise Owner in writing, describing efforts to correct situation, and provide analysis of cause for problem. If necessary to resolve problem, provide at no cost services of manufacturer's engineering and technical staff at site in a timely manner to analyze warranty issues, and develop recommendations for correction, for review and approval by Owner.

- C. Items of equipment which have longer guarantees, as called for in these specifications or as otherwise offered by the manufacturer, such as generators, engines, batteries, transformers, etc., shall have warranties and guarantees completed in order, and shall be in effect at the time of final acceptance of the work by the Engineer.

## **PART 2 - PRODUCTS:**

### **2.1 GENERAL**

- A. Materials used shall present no environmental or toxicological hazards as defined by current industry standards and shall comply with OSHA and EPA standards, other applicable federal, state, and local laws.
- B. Product numbers are subject to change by the manufacturer without notification. In the event a product number is invalid or conflicts with the written description, notify the Engineer in writing prior to ordering the material and performing installation work.
- C. Except where specifically noted otherwise, all equipment supplied by the Contractor shall be the standard products of a single manufacturer of known reputation and experience in the industry. Only equipment, components and accessories in current production for at least five (5) years beyond the completion date of this system shall be used and installed. Any equipment found to be obsolete or not in future production will be removed and replaced at Contractor's expense. This includes all equipment, materials and labor.

### **2.2 SUBSTITUTIONS**

- A. Conform to the substitutions requirements and procedures outlined in Division 01.
- B. Only one substitution for each product specified will be considered and substitutions must be submitted to Engineer a minimum of **10 days** prior to bid using the standard CSI substitution request form.
- C. Where products are noted as "or equal", a product of equivalent design, manufacture, and performance will be considered. Submit product data (product information, catalog cuts, pertinent test data, etc.) to substantiate that the product is in fact equivalent to that specified. The burden of proof that the substituted product is equivalent to the specified product rests with the Contractor. Whenever material, process or equipment is specified in accordance with an industry specification (ANSI, TIA, etc), UL rating, or other association standard, present an affidavit from the manufacturer certifying that the product complies with the particular standard specification. When requested by the Engineer, submit supporting test data to substantiate compliance.
- D. Manufacturers' names and model numbers used in conjunction with materials, processes or equipment included in the contract documents are used to establish standards of quality, utility and appearance. Materials, processes or equipment that, in the opinion of the Engineer, are equivalent in quality, utility and appearance will be

approved as substitutions to that specified when "or equal" follows the manufacturers' names or model number(s).

- E. Any drawings, specifications, diagrams, calculations, etc required to describe and coordinate such substitutions or deviations shall be professionally prepared at the expense of the responsible Contractor.
- F. Whenever equipment or materials are specified exclusively, only such items shall be used unless substitution is accepted in writing by the Engineer.
- G. When the Engineer accepts a substitution in writing, it is with the understanding that the Contractor guarantees the substituted product, component, article, or material to be equivalent to the one specified and dimensioned to fit within the construction according to contract documents. Do not provide substituted material, processes, or equipment without written authorization from the Engineer. Assumptions on the acceptability of a proposed substitution, prior to acceptance by the Engineer, are at the sole risk of the Contractor.
- H. Approved substitutions shall not relieve the Contractor of responsibilities for the proper execution of the work, or from provisions of the specifications.
- I. Contractor shall pay expenses, without additional charge to the Owner, in connection with substitution materials, processes and equipment, including the effect of substitution on self, subcontractor's or other Contractor's work.
- J. Contractor shall be responsible and assume all costs for removal and replacement of any substituted product installed without prior written approval. Such costs shall include, but not be limited to labor, materials as well as any penalties, fees or costs incurred for late completion.

### **PART 3 - EXECUTION:**

#### **3.1 EXAMINATION**

- A. Verify existing conditions, stated under other sections, are acceptable for installation in accordance with manufacturer's instructions.

#### **3.2 INSTALLATION**

- A. Comply with NECA 1
- B. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications' equipment and other nearby installations. Connect in such a way as to facilitate future maintenance with minimum interference from other items in the vicinity.
- C. The Contractor shall be responsible for all necessary lines, levels, elevations and measurements required to lay out their work. Verify the figures shown on the drawings

before laying out the work. The Contractor shall be held responsible for any error resulting from his failure to do so.

- D. The Contractor shall base all measurements, both horizontal and vertical from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at site and check the correctness of same as related to the work.
- E. Should the Contractor discover any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the drawings and specifications, he shall notify the Engineer thru normal channels of job communication and shall not proceed with his work until he has received instructions from the Engineer.

### 3.3 TEMPORARY USE OF EQUIPMENT

- A. The permanent electrical equipment, (except lighting), when installed, may be used for temporary services, subject to an agreement among the Contractors involved, the Owner, and with the consent of the Engineer. Should the permanent systems be used for this purpose, each Contractor shall pay for all temporary connections required and any replacements required due to damage without cost, leaving the equipment and installation in "as new" condition. The Contractor may be required to bear utility costs, user fees, etc.
- B. Permission to use the permanent equipment does not relieve the Contractors who utilize this equipment from the responsibility for any damages to the building construction and/or equipment which might result because of its use.

### 3.4 TEMPORARY SERVICES

- A. The Contractor shall arrange for temporary electrical and other services which he may require to accomplish his work. In the absence of other provisions in the contract, the Contractor shall provide for his own temporary services of all types, including the cost of connections, utility company fees, construction, removal, etc., in his bid.
- B. All temporary services shall be removed by Contractor prior to acceptance of work.

### 3.5 PROTECTION OF EQUIPMENT

- A. The Contractor shall be entirely responsible for all material and equipment furnished by him in connection with his work and special care shall be taken to properly protect all parts thereof from damage during the construction period. Such protection shall be by a means acceptable to the Engineer. All rough-in conduit shall be properly plugged or capped during construction in a manner approved by the Engineer. Equipment damaged while stored on site either before or after installation shall be repaired or replaced (as determined by the Engineer) by the responsible Contractor. Electrical equipment exposed to the weather shall be replaced by the Contractor at his expense.

### 3.6 CONCRETE WORK

- A. The Contractor shall be responsible for the provision of all concrete work required for the installation of any of his systems or equipment. If this work is provided by another trade, it will not relieve the Electrical Contractor of his responsibilities relative to dimensions, quality of workmanship, locations, etc. In the absence of other concrete specifications, all concrete related to Electrical work shall be 3000 PSI minimum compression strength at 28 days curing and shall conform to the standards of the American Concrete Institute Publication ACI-318. Heavy equipment shall not be set on pads for at least seven days after pour.
- B. All concrete pads shall be complete with all pipe sleeves, embeds, anchor bolts, reinforcing steel, concrete, etc., as required. Pads larger than 18" in width shall be reinforced with minimum #4 round bars on 6" centers both ways. All reinforcing steel shall be per ASTM requirements, tied properly, lapped 18 bar diameters and supported appropriately up off form, slab or underlayment. Bars shall be approximately 3" above the bottom of the pad with a minimum 2" cover. All parts of pads and foundations shall be properly rodded or vibrated. If exposed parts of the pads and foundations are rough or show honeycomb after removing forms properly adhered repairs shall be made. If structural integrity is violated, the concrete shall be replaced. All surfaces shall be rubbed to a smooth finish.
- C. All pads and concrete lighting standard bases shall be crowned slightly so as to avoid water ponding beneath equipment.
- D. Unless noted otherwise, concrete pads for small equipment shall extend 6" beyond the equipment's base dimensions. For large equipment with service access panels, extend pads 18" beyond base or overall dimensions to allow walking and servicing space at locations requiring service access.
- E. Exterior concrete pads shall be 4" minimum above grade and 4" below grade on a tamped 4" dense grade rock base unless otherwise noted or required by utility company. Surfaces of all foundations and bases shall have a smooth finish with three-quarter inch radius or chamfer on exposed edges, troweled or rubbed smooth. All exterior pads shall be crowned approximately 1/8" per foot, sloping from center for drainage.

### 3.7 MAINTENANCE OF EXISTING UNDERGROUND UTILITIES

- A. The locations of all piping, conduits, cables, utilities and manholes existing, or otherwise, that come within the contract construction site, shall be subject to continuous uninterrupted maintenance with no exception unless the Owner of the utilities grants permission to interrupt same temporarily, if need be. Provide one week's written notice to Engineer, Architect and Owner prior to interrupting any utility service or line. Also see Paragraph 1.2 - SUMMARY, of this specification.
- B. Known utilities and lines as available to the Engineer are shown on the drawings. However, it is additionally required that, prior to any excavation being performed, each Contractor ascertain and mark all utilities or lines that would be endangered by the excavation. Contractor shall bear costs of repairing damaged utilities.

- C. If the above-mentioned utilities or lines occur in the earth within the construction site, the Contractor shall first probe and make every effort to locate the lines prior to excavating in the respective area.
- D. Cutting into existing utilities and services shall be done in coordination with and as designated by the Owner of the utility. The Contractor shall work continuously to restore service(s) upon deliberate or accidental interruption, providing premium time and materials as needed without extra claim to the Owner.
- E. The Contractor shall repair to the satisfaction of the Engineer any surface or subsurface improvements damaged during the course of the work, unless such improvement is shown to be abandoned or removed.
- F. Machine excavation shall not be permitted within ten feet of existing gas or fuel lines. Hand excavate only in these areas, in accord with utility company, agency or other applicable laws, standards or regulations.
- G. Protect all new or existing lines from damage by traffic, etc. during construction.

### 3.8 SMOKE AND FIREPROOFING

- A. The Contractor shall not penetrate rated fire walls, ceilings or floors with conduit, cable, bus duct, wireway or other raceway system unless all penetrations are protected in a code compliant manner which maintains the rating of the assembly. Smoke and fire stop all openings made in walls, chases, ceiling and floors. Patch all openings around conduit, wireway, bus duct, etc., with appropriate type material to smoke stop walls and provide needed fire rating at fire walls, ceilings and floors. Smoke and fire proofing materials and method of application shall be approved by the local authority having jurisdiction. Refer to architectural plans and specifications for further requirements.
- B. Contractor to provide heat detectors in the area of construction with complete fire detection until fire alarm system is operational and construction is complete.
- C. Fire-stopping materials and installation shall be by a single source through-out the project, by all trades.
- D. All fire-stopping assemblies must be UL listed. Provide shop drawings indicating penetration detail for each type of wall and floor construction. Shop drawings must be specific for each individual type (i.e., one-hour fire rated gypsum wall board with insulated metal pipe penetration.) and must indicate a UL listing for the complete fire-stopping assembly.
- E. 3M fire protection products are listed below. Equivalent products may be submitted if they are UL listed.
- F. All of the fire-stopping shall be applied by a Contractor who is certified by the manufacturer of the fire-stopping product for installation of the product.
- G. Fire-stopping materials to include but not limited to the following:
  - 1. 3M fire barrier FS-195 wrap/strip.
  - 2. 3M fire barrier CP 25 caulk.
  - 3. 3M fire barrier MP moldable putty.
  - 4. 3M fire barrier RC-1 restricting collar with steel hose clamp.
  - 5. 3M fire barrier damming materials.
  - 6. 3M fire barrier CS-195 composite sheet.

7. 3M fire barrier fire dam 150 caulk.
8. Steel sleeves.

### 3.9 QUIET OPERATION, SUPPORTS, VIBRATION AND OSCILLATION

- A. All work shall operate under all conditions of load without any objectionable sound or vibration, the performance of which shall be determined by the Engineer. Noise from moving machinery or vibration noticeable outside of room in which it is installed, or annoyingly noticeable noise or vibration inside such room, will be considered objectionable. Sound or vibration conditions considered objectionable by the Engineer shall be corrected in an approved manner by the Contractor (or Contractors responsible) at his expense.
- B. All equipment subject to vibration and/or oscillation shall be mounted on vibration supports suitable for the purpose of minimizing noise and vibration transmission, and shall be isolated from external connections such as piping, ducts, etc., by means of flexible connectors, vibration absorbers or other approved means. Surface mounted equipment such as panels, switches, etc., shall be affixed tightly to their mounting surface.
- C. The Contractor shall provide supports for all equipment furnished by him using an approved vibration isolating type as needed. Supports shall be liberally sized and adequate to carry the load of the equipment and the loads of attached equipment, piping, etc. All equipment shall be securely fastened to the structure either directly or indirectly through supporting members by means of bolts or equally effective means. No work shall depend on the supports or work of unrelated trades unless specifically authorized in writing by the Architect or Engineer.

### 3.10 FINAL CONNECTIONS TO EQUIPMENT

- A. The roughing-in and final connections to all electrically operated equipment furnished under this and all other sections of the contract documents or by others, shall be included in the Contract and shall consist of furnishing all labor and materials for connection. The Contractor shall carefully coordinate with equipment suppliers, manufacturer's representatives, the vendor or other trades to provide complete electrical and dimensional interface to all such equipment (kitchen, hoods, mechanical equipment, panels, refrigeration equipment, etc.)

### 3.11 WELDING

- A. The Contractor shall be responsible for quality of welding done by his organization and shall repair or replace any work not done in accordance with the Architect's or structural Engineer's specifications for such work. If required by the Engineer, the responsible Contractor shall cut at least three welds during the job for X-raying and testing. These welds are to be selected at random and shall be tested as a part of the responsible Contractor's work. Certification of these tests and X-rays shall be submitted, in triplicate, to the Engineer. In case a faulty weld is discovered, the Contractor shall be required to furnish additional tests and corrective measures until satisfactory results are obtained.

### 3.12 ACCESSIBILITY

- A. The Contractor shall be responsible for the sufficiency of the size of shafts and chases, the adequate clearance in partitions and above suspended ceilings for the proper installation of his work. He shall cooperate with the General Contractor (or Construction Manager) and all other Contractors whose work is in the same space, and shall advise each Contractor of his requirements. Such spaces and clearances shall be kept to the minimum size required to ensure adequate clearance and access.
- B. The Contractor shall locate all equipment which must be serviced, operated, or maintained in fully accessible positions. Equipment shall include but not be limited to junction boxes, pull boxes, contactors, panels, disconnects, controllers, switchgear, etc. Minor deviations from drawings may be made to allow for better accessibility, and any change shall be approved where the equipment is concealed.
- C. Each Contractor shall provide (or arrange for the provision by other trades) the access panels for each concealed junction box, pull box, fixtures or electrical device requiring access or service as shown on Engineer's plans or as required. Locations of these panels shall be identified in sufficient time to be installed in the normal course of work. All access panels shall be installed in accord with the Architect's standards for such work. In the absence of such specifications, at a minimum such work shall comply with the specifications below. All locations for access panels which are not specifically indicated on the drawings shall be submitted to and approved by the architect prior to ordering.
- D. Access Doors; in Ceilings or Walls:
  - 1. In mechanical, electrical and service spaces: 14-gauge aluminum brushed satin finish, 1" border.
  - 2. In finished areas: 14-gauge primed steel with 1" border to accept the architectural finishes specified for the space. Confirm these provisions with the Architect prior to obtaining materials or installing any such work.
- E. In fire or smoke rated partitions, access doors shall be provided that equal or exceed the required rating of the construction they are mounted in.

### 3.13 ELECTRICAL CONNECTIONS

- A. The Contractor shall furnish and install all power wiring complete from power source to motor or equipment junction box, including power wiring through starters. The Contractor shall install all starters not factory mounted on equipment. Unless otherwise noted, the supplier of equipment shall furnish starters with the equipment. Also, refer to Division 20, 21, 22, 23, 24, 25, 26, 27, and 28 of Specifications, shop drawings and equipment schedules for additional information and requirements.
- B. All control, interlock, sensor, thermocouple and other wiring required for equipment operation shall be provided by the Contractor. All such installations shall be fully compliant with all requirements of Division 26, 27 and 28 regardless of which trade actually installs such wiring. Motors and equipment shall be provided for current and voltage characteristics as indicated or required. All wiring shall be enclosed in raceways unless otherwise noted.

- C. Each Contractor or Sub-Contractor, prior to bidding the work, shall coordinate power, control, sensor, interlock and all other wiring requirements for equipment or motors with all other contractors or sub-contractors, to ensure all needed wiring is provided in the Contract. Failure to make such coordination shall not be justification for claims of extra cost or a time extension to the Contract.

### 3.14 MOTORS

- A. Each motor shall be provided by the equipment supplier, installer or manufacturer with conduit terminal box and NEC required disconnecting means as indicated or required. Three-phase motors shall be provided with external thermal overload protection in their starter units. Single-phase motors shall be provided with thermal overload protection, integral to their windings or external, in control unit. All motors shall be installed with NEMA-rated starters as specified and shall be connected per the National Electrical Code.
- B. The capacity of each motor shall be sufficient to operate associated driven devices under all conditions of operation and load and without overload, and at least of the horsepower indicated or specified. Each motor shall be selected for quiet operation, maximum efficiency and lowest starting KVA per horsepower as applicable. Motors producing excessive noise or vibration shall be replaced by the responsible contractor. Refer to Division 20, 21, 22, 23 and 25 of the Specifications for further requirements and scheduled sizes.
- C. All three-phase motors shall be tested for proper rotation. Correct wiring if needed and retest. Document testing and corrective action in operations and maintenance manual.

### 3.15 SLEEVES AND PLATES

- A. Each Contractor shall provide and locate all sleeves and inserts required for his work before the floors and walls are built, or shall be responsible for the cost of cutting and patching required where sleeves and inserts were not installed, or where incorrectly located. Each Contractor shall do all drilling required for the installation of his hangers. Drilling of anchor holes may be prohibited in post-tensioned concrete construction, in which case the Contractor shall request approved methods from the Architect and shall carefully coordinate setting of inserts, etc., with the Structural Engineer and/or Architect.
- B. Sleeves shall be provided for all electrical conduit passing thru concrete floor slabs and concrete, masonry, tile and gypsum wall construction. Sleeves shall not be provided for piping running embedded in concrete or insulating concrete slabs on grade, unless otherwise noted.
- C. Where sleeves are placed in exterior walls below grade, the space between the pipe or conduit and the sleeves shall be packed with oakum and lead, mechanical water stop or other approved material and made completely water tight by a method approved by the Engineer and/or Architect.
- D. Where conduit motion due to expansion and contraction will occur, make sleeves of sufficient diameter to permit free movement of pipe. Check floor and wall construction finishes to determine proper length of sleeves for various locations; make actual lengths to suit the following:

1. Terminate sleeves flush with walls, partitions and ceiling.
  2. In areas where pipes are concealed, as in chases, terminate sleeves flush with floor.
  3. In all areas where pipes are exposed, extend sleeves 1/2 inch above finished floor, except in rooms having floor drains, where sleeves shall be extended 3/4 inches above floor.
- E. Sleeves shall be constructed of 24-gauge galvanized sheet steel with lock seam joints for all sleeves set in concrete floor slabs terminating flush with the floor. All other sleeves shall be constructed of galvanized steel pipe unless otherwise indicated on the drawings.
- F. Fasten sleeves securely in floors, walls, so that they will not become displaced when concrete is poured or when other construction occurs around them. Take precautions to prevent concrete, plaster or other materials being forced into the space between pipe and sleeve during construction. Fire and smoke stop all sleeves in a manner approved by the local authority having jurisdiction or per prevailing codes.

### 3.16 ANCHORS

- A. Each Contractor shall provide and locate all inserts required for his work before the floors and walls are built, or shall be responsible for the cost of cutting and patching required where inserts were not installed, or where incorrectly located. Each Contractor shall do all drilling required for the installation of his hangers. Drilling of anchor holes may be prohibited in post-tensioned concrete construction, in which case the Contractor shall request approved methods from the Architect and shall carefully coordinate setting of inserts, etc., with the Structural Engineer and/or Architect.

### 3.17 WEATHERPROOFING

- A. Where any work pierces waterproofing, including waterproof concrete, the method of installation shall be as approved by the Architect and/or Engineer before work is done. The Contractor shall furnish all necessary sleeves, caulking and flashing required to make openings absolutely watertight.
- B. Wherever work penetrates roofing, it shall be done in a manner that will not diminish or void the roofing guarantee or warranty in any way. Coordinate all such work with the roofing installer.

### 3.18 CONDUIT MOUNTING HEIGHTS

- A. All exposed or concealed conduit, raceways, etc., shall be held as high as possible unless otherwise noted and coordinated with all other trades. Exposed conduit shall, insofar as possible, run perpendicular or parallel to the building structure.

3.19 PAINTING

- A. Each fixture device, panel, junction box, etc., that is located in a finished area shall be provided with finish of color and type as selected or approved by the Architect or Engineer. If custom color is required, it shall be provided at no additional cost to the Owner. All other equipment, fixtures or devices located in finished or unfinished areas, that are not required to have or are provided with finish color or coating shall be provided in a prime painted condition, ready to receive finish paint or coating. All galvanized metal in finished areas shall be properly prepared with special processes to receive finish paint as directed and approved by the Architect.

3.20 SCAFFOLDING, RIGGING AND HOISTING

- A. The Contractor shall furnish all scaffolding, rigging, hoisting, and services necessary for erection and delivery into the premises of any equipment and apparatus furnished. All such temporary appurtenances shall be set up in strict accord with OSHA Standards and Requirements. Remove same from premises when no longer required.

3.21 INDEMNIFICATION

- A. The Contractor shall hold harmless and indemnify the Engineer, employees, officers, agents and consultants from all claims, loss, damage, actions, causes of actions, expense and/or liability resulting from, brought for, or on account of any personal injury or property damage received or sustained by any person, persons, (including third parties), or any property growing out of, occurring, or attributable to any work performed under or related to this contract, resulting in whole or in part from the negligence of the Contractor, any subcontractor, any employee, agent or representative.

3.22 HAZARDOUS MATERIALS

- A. The Contractor is hereby advised that it is possible that asbestos and/or other hazardous materials are or were present in this building(s). Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of his work, insure that his workers are aware of this potential and what they are to do in the event of suspicion. He shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.
- B. Any worker, occupant, visitor, inspector, etc., who encounters any material of whose content they are not certain shall promptly report the existence and location of that material to the Contractor and/or Owner. The Contractor shall, as a part of their work, insure that their workers are aware of this potential and what they are to do in the event of suspicion. The Contractor shall also keep uninformed persons from the premises during construction. Furthermore, the Contractor shall insure that no one comes near

to or in contact with any such material or fumes therefrom until its content can be ascertained to be non-hazardous.

- C. CMTA, Inc., Consulting Engineers, have no expertise in the determination of the presence of hazardous materials. Therefore, no attempt has been made by them to identify the existence or location of any such material. Furthermore, CMTA nor any affiliate thereof will neither offer nor make any recommendations relative to the removal, handling or disposal of such material.
- D. If the work interfaces, connects or relates in any way with or to existing components which contain or bear any hazardous material, asbestos being one, then, it shall be the Contractor's sole responsibility to contact the Owner and so advise him immediately.
- E. The Contractor by execution of the contract for any work and/or by the accomplishment of any work thereby agrees to bring no claim relative to hazardous materials for negligence, breach of contract, indemnity, or any other such item against CMTA, its principals, employees, agents or consultants. Also, the Contractor further agrees to defend, indemnify and hold CMTA, its principals, employees, agents and consultants, harmless from any such related claims which may be brought by any subcontractors, suppliers or any other third parties.

### 3.23 ABOVE-CEILING AND FINAL PUNCH LISTS

- A. The Contractor shall review each area and prepare a punch list for each of the subcontractors, as applicable, for at least two stages of the project.
  - 1. For review of in-wall work that will be concealed by drywall or other materials well before substantial completion.
  - 2. For review of the above-ceiling work that will be concealed by tile or other materials well before substantial completion.
  - 3. For review of all other work as the project nears substantial completion.
- B. When all work from the Contractor's punch list is complete at each of these stages and prior to completing ceiling installations (or at the final punch list stage), the Contractor shall request that the Engineer develop a punch list. This request is to be made in writing two weeks prior to the proposed date. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list and all work prior to the ceilings being installed and at the final punch list review.
- C. After all corrections have been made from the Engineer's punch list, the Contractor shall review and initial off on each item. This signed-off punch list shall be submitted to the Engineer. The Engineer shall return to the site once to review each punch list and all work prior to the ceilings being installed and at the final punch list review.
- D. At the engineer's option, the contractor shall supply digital photographs via email or file-share of any installed work.
- E. If additional visits are required by the Engineer to review work not completed by this review, the Engineer shall be reimbursed directly by the Contractor by check or money order (due 10 days from date of each additional visit) at a rate of \$125.00 per hour for extra trips required to complete either of the above-ceiling or final punch lists.

- F. All panelboard fronts shall be omitted until final punch list inspection is made. Directories for each panelboard shall be completed and available for review by the Engineer at that time.

### 3.24 EQUIPMENT/SYSTEMS TESTING, VERIFICATION & START-UP

- A. The Contractor (and Sub-Contractors) shall be responsible for commissioning, starting-up, testing, checking, examining, inspecting, etc. their own systems.
- B. The Electrical Contractor shall designate an individual under his employment to lead the start-up, testing and verification process. This person should not be the project manager or job site superintendent, but a person dedicated to making this critical task successful and completed in a timely manner.
- C. This individual shall also be responsible for the following items:
  - 1. All identification and labeling requirements per plans and specifications.
  - 2. Submission of switchgear coordination study, fault current study, and arc flash hazard analysis.
- D. A pre-start-up conference shall be held with the Architect, Owner, Construction Manager, Electrical Contractor, and the Manufacturers providing startup services. The purpose of this meeting will be to discuss the goals, procedures, etc. for start-up.
- E. A specific line-item shall be included on the schedule of values for testing and verification of all systems indicated in this section. This line-item value shall be approved by the Engineer. The Engineer, Owner and the Engineer's Field Inspector(s) shall closely monitor progress and quality of the testing, verification, and startup and may withhold pay requests as deemed appropriate.
- F. The Contractor shall test all wiring and connections for continuity and grounds before equipment and fixtures are connected, and when indicated or required, demonstrate by Megger Test the insulation resistance of any circuit or group of circuits. Where such tests indicate the possibility of faulty insulation, locate the point of such fault, pull out the defective conductor, replacing same with new and demonstrate by further test the elimination of such defect.
- G. Systems Requiring Testing & Verification:
  - 1. Fire Alarm System
  - 2. Electrical Distribution Equipment
  - 3. Lighting and Lighting Controls
  - 4. Emergency Standby Systems
  - 5. All Low Voltage Systems
  - 6. Grounding Systems
  - 7. Wiring and Terminations
- H. The Contractor shall include in the bid to provide systems startup and verification for ALL electrical systems specified for this project. Specific startup, testing, and verification specifications are included throughout the Electrical specifications. In general, as part of the verification process, equipment suppliers shall perform start-up by their factory authorized technicians (not third-party Contractors) and shall complete and submit start-up reports/checklists. Submit start-up reports to the Engineer. The Contractor shall have appropriate trades on site to correct all deficiencies noted by the factory representative. For each deficiency noted, documentation of corrective action

(including date and time) shall be submitted to the Engineer and Owner. Where factory start-up is not specified for a particular piece of equipment or system, the Contractor shall be responsible to perform start-up.

- I. The Contractor shall be responsible for completion of System Verification Checklist (SVC) / Manufacturer's Checklists. Furnish to the Testing Agent and Engineer. Sample checklists shall be submitted to the Engineer, Owner, and Testing Agent for approval.
- J. The completed reports shall be organized and bound together in a tabbed binder and submitted for review and approval.

### 3.25 SPECIAL WRENCHES, TOOLS AND KEYS

- A. Each Contractor shall provide, along with the equipment provided, any special wrenches or tools necessary to dismantle or service equipment or appliances installed by him. Wrenches shall include necessary keys, handles and operators for valves, switches, breakers, etc. and keys to electrical panels, emergency generators, alarm pull boxes and panels, etc. At least two (2) of any such special wrench, keys, etc. shall be turned over to the Architect prior to completion of the project. Obtain a receipt that this has been accomplished and forward a copy to the Engineer.

### 3.26 FIELD QUALITY CONTROL

- A. Before requesting a final review of the installation from the Architect and/or Engineer, the Contractor shall thoroughly inspect his installation to assure that the work is complete in every detail and that all requirements of the Contract Documents have been fulfilled. Failure to accomplish this may result in charges from the Architect and/or Engineers for unnecessary and undue work on their part.
- B. Owner's and Engineer's inspections: Two (2) inspections will be held to generate and then review punchlist items. All site inspections and visits thereafter shall be billed to the Contractor at the Engineer's standard hourly rates.
- C. The Contractor shall provide as a part of this contract electrical inspection by a competent Electrical Inspection Agency, licensed to provide such services. The name of this agency shall be included in the list of materials of the Form of Proposal by the Contractor. All costs incidental to the provision of electrical inspections shall be borne by the Electrical Contractor.
- D. The Contractor shall advise each Inspection Agency in writing (with an information copy of the correspondence to the Architect and/or Engineer) when he anticipates commencing work. Failure of the Inspection Agency to inspect the work in the stage following and submit the related reports may result in the Contractor's having to expose concealed work not so inspected. Such exposure will be at the expense of the responsible Contractor.
- E. Inspections shall be scheduled for rough as well as finished work. The rough inspections shall be divided into as many inspections as may be necessary to cover all roughing-in without fail. Report of each such inspection visit shall be submitted to the Architect, Engineer and the Contractor within three days of the inspection.

- F. Approval by an Inspector does not relieve the Contractor from the responsibilities of furnishing equipment having a quality of performance equivalent to the requirements set forth in these plans and specifications. All work under this contract is subject to the review of the Architect and/or Engineer, whose decision is binding.
- G. Before final acceptance, the Contractor shall furnish three (3) copies of the certificates of final approval by the Electrical Inspector (as well as all other inspection certificates) to the Engineer with one (1) copy of each to the appropriate government agencies, as applicable. Final payment for the work shall be contingent upon completion of this requirement.

### 3.27 CLEANING

- A. In addition to cleaning requirements in Division 01 and 26, thoroughly clean exposed portions of equipment upon completion of installation. Remove temporary labels and traces of foreign substances. Remove construction debris and surplus materials accumulated during work.
- B. Leave finished work and adjacent surfaces in neat, clean condition with no evidence of damage.
- C. Repair or replace damaged installed products.

### 3.28 OWNER TRAINING

- A. Upon completion of all work and all tests, Contractor shall provide classroom and in the field training for each type and/or model of equipment installed. Training shall be led by qualified factory certified technician. Contractor shall submit a request to schedule training sessions a minimum of two weeks in advance. Submission shall include qualifications of instructor as well as a syllabus that the Owner will add/deduct to as they see fit. Each individual listed as an "Attendee" on the roster submitted by the Owner shall receive a copy of the maintenance manual to review during training. All training sessions shall be recorded and a DVD with proper labels identifying the date, equipment, and project shall be delivered prior to Completion of the project. If the audio from the recording is unclear, narration shall be added. The Contractor shall certify in writing to the Engineer that such demonstrations have taken place, noting the date, time and names of the Owner's representative that were present.
- B. The training phase shall be accompanied by complete as-built documentation and the technical systems operation manual.
- C. These training sessions shall be videotaped by the Installer and copies provided to the Owner within one (1) week of training
- D. Brochures: Furnish Owner a complete set of operating instructions and diagrams.
- E. Systems/Components which require owner training. The training shall be accomplished by a factory trained representative. Include (8) hours minimum for each system described here-in. Each equipment representative shall be represented wherever their equipment is used. All training shall be videotaped by the Installer. The following systems shall include owner training at a minimum:

1. Lighting control system
  2. Generator and Automatic Transfer Switches
  3. Electrical Distribution (Switchgear)
  4. Service Grounding
  5. Electrical Devices
  6. Fire Alarm Materials & Labor
- F. Instruction Program: Submit outline of instructional program for demonstration and training, including a schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include learning objective and outline for each training module.
- G. At completion of training, submit two complete training manual(s) for Owner's use.
- H. Qualification Data: For facilitator, instructor and photographer.
- I. Attendance Record: For each training module, submit list of participants and length of instruction time.
- J. Evaluations: For each participant and for each training module, submit results and documentation of performance-based test.
- K. Demonstration and Training DVDs: Submit two copies within seven days of end of each training module.
- L. Identification: On each copy, provide an applied label with the following information:
1. Name of Project.
  2. Name and address of photographer.
  3. Name of Architect and Construction Manager.
  4. Name of Contractor.
  5. Date video was recorded.
  6. Description of vantage point, indicating location, direction (by compass point), and elevation or story of construction.
- M. Transcript: Prepared on 8-1/2-by-11-inch paper, punched and bound in heavy duty, 3-ring, vinyl-covered binders. Mark appropriate identification on front and spine of each binder. Include a cover sheet with same label information as the corresponding video. Include name of Project and date of video on each page.

### 3.29 SYSTEM ACCEPTANCE

- A. System cannot be considered for acceptance until work is completed and demonstrated to Engineer that installation is in strict compliance with Specifications, Drawings and manufacturer's installation instructions, particularly in reference to following:
1. Testing Reports
  2. Cleaning
  3. Operation and Maintenance Manuals
  4. Training of Operating Personnel
  5. Record Drawings
  6. Warranty Certificates, including extended manufacturer's warranties.

**END OF SECTION**

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## **SECTION 26 05 13**

### **MEDIUM-VOLTAGE CABLES**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section includes cables and related cable splices, terminations, and accessories for medium-voltage (2001 to 35,000 V) electrical distribution systems.

##### **1.3 DEFINITIONS**

- A. Jacket: A continuous nonmetallic outer covering for conductors or cables.
- B. NETA ATS: Acceptance Testing Specification.
- C. Sheath: A continuous metallic covering for conductors or cables.

##### **1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

##### **1.5 QUALITY ASSURANCE**

- A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

##### **1.6 FIELD CONDITIONS**

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Owner no fewer than five days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.

## **PART 2 - PRODUCTS**

### **2.1 SYSTEM DESCRIPTION**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with IEEE C2 and NFPA 70.
- C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

### **2.2 CABLES**

- A. Subject to compliance with requirements, provide products from one of the following:
  1. General Cable
  2. Okonite
  3. Southwire
- B. Cable Type: Type MV 90.
- C. Conductor Insulation: Crosslinked polyethylene.
  1. Voltage Rating: 15 kV.
  2. Insulation Thickness: **133** percent insulation level.
- D. Conductor: Copper.
- E. Comply with UL 1072, AEIC CS8, ICEA S-93-639/NEMA WC 74, and ICEA S-97-682.
- F. Conductor Stranding: Compact round, concentric lay, Class B.
- G. Strand Filling: Conductor interstices are filled with impermeable compound.
- H. Shielding: Copper tape, helically applied over semiconducting insulation shield.
- I. Cable Jacket: Sunlight-resistant PVC.

## 2.3 CONNECTORS

- A. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.
- B. Copper-Conductor Connectors: Copper barrel crimped connectors.

## 2.4 SEPARABLE INSULATED CONNECTORS

- A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- C. Dead-Break Cable Terminators: Elbow-type unit with **600-A** continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
- D. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.
  - 1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
  - 2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
  - 3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
  - 4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.
- E. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.
- F. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

## 2.5 SPLICE KITS

- A. Description: For connecting medium voltage cables; type as recommended by cable or splicing kit manufacturer for the application.

- B. Standard: Comply with IEEE 404.
- C. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
  - 1. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
  - 2. Separable multiway splice system with all components for the required splice configuration.

## 2.6 MEDIUM-VOLTAGE TAPES

- A. Description: Electrical grade, insulating tape rated for medium voltage application.
- B. Ethylene/propylene rubber-based, 30-mil (0.76-mm) splicing tape, rated for 130 deg C operation. Minimum 3/4 inch (20 mm) wide.
- C. Silicone rubber-based, 12-mil (0.30-mm) self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inches (38 mm) wide.

## 2.7 SOURCE QUALITY CONTROL

- A. Test and inspect cables according to ICEA S-97-682 before shipping.
- B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

# **PART 3 - EXECUTION**

## 3.1 INSTALLATION

- A. Install cables according to IEEE 576.
- B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inches (1200 to 1800 mm) on the pull rope.
  - 1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
  - 2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.

- C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
  - 1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
  - 2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
  - 3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
  - 4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.
- D. Install "buried-cable" warning tape 12 inches above cables.
- E. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.
- F. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.
- G. Install cable splices at pull points and elsewhere as indicated; use standard kits. Use dead-front separable watertight connectors in manholes and other locations subject to water infiltration.
- H. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.
- I. Install separable insulated-connector components as follows:
  - 1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
  - 2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
  - 3. Standoff Insulator: At each terminal junction, with one on each terminal.
- J. Install fault indicators on each phase where indicated.
- K. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.
- L. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.
- M. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

### 3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
  - 2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
  - 3. Perform direct-current High Potential test of each new conductor according to NETA ATS, Ch. 7.3.3. Do not exceed cable manufacturer's recommended maximum test voltage.
  - 4. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
  - 5. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
- B. Medium-voltage cables will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

**END OF SECTION**

## **SECTION 26 05 19**

### **LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Copper building wire rated 600 V or less.
  - 2. Metal-clad cable, Type MC, rated 600 V or less.
  - 3. Connectors, splices, and terminations rated 600 V and less.

##### **1.3 DEFINITIONS**

- A. RoHS: Restriction of Hazardous Substances.
- B. VFC: Variable-frequency controller.

##### **1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Product Schedule: Indicate type, use, location, and termination locations.

#### **PART 2 - PRODUCTS:**

##### **2.1 COPPER BUILDING WIRE**

- A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
  2. RoHS compliant.
  3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- C. Conductors: 98% conductive annealed copper, complying with ASTM B 3 for bare annealed copper and with **ASTM B 8** for stranded conductors.
- D. Conductor Insulation:
1. Type THHN and Type THWN-2: Comply with UL 83.
  2. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
  3. Type UF: Comply with UL 83 and UL 493.
  4. Type XHHW-2: Comply with UL 44.

## 2.2 METAL-CLAD CABLE, TYPE MC

- A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
- B. Standards:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
  2. Comply with UL 1569.
  3. RoHS compliant.
  4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- C. Circuits:
1. Single circuit with color-coded conductors.
  2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.
- D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors
- E. Ground Conductor: Insulated.
- F. Conductor Insulation:
1. Type TFN/THHN/THWN-2: Comply with UL 83.
  2. Type XHHW-2: Comply with UL 44.
- G. Armor: Steel, interlocked.

## 2.3 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Connectors:
  - 1. Twist-on spring pressure type, 600V, 105°C insulation for wire sizes up to #8.
  - 2. For wire sizes #6 or greater, compression type connection, 600v insulation, covered with cold shrink tubing and taped to restore full insulation value of wire being spliced.
- C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
- D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
  - 1. Material: Copper.
  - 2. Type: Two hole with long barrels.
  - 3. Termination: Compression.

## **PART 3 - EXECUTION:**

### 3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Feeders: Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- C. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- D. Connections for motors or vibrating and oscillating equipment: Extra-flexible stranded for all sizes.
- E. Power-Limited Fire Alarm and Control: Stranded for all sizes.

### 3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN/THWN-2, single conductors in raceway

- B. Exposed or Concealed Feeders in dry or damp locations: Type THHN/THWN-2, single conductors in raceway
- C. Feeders Concealed in Concrete, below Slabs-on-Grade, Underground, or other wet locations: Type THWN-2, single conductors in raceway.
- D. Exposed Branch Circuits in dry or damp locations: Type THHN/THWN-2, single conductors in raceway.
- E. Concealed Branch Circuits in dry locations: Type THHN/THWN-2, single conductors in raceway or MC cable.
  - 1. MC Cable is not acceptable for the following applications:
    - a. Branch circuits for Fire Alarm or other life safety devices
    - b. Branch circuits for HVAC or elevator devices
    - c. Exposed Areas with no ceiling
    - d. Wet Locations.
- F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, Underground or other wet locations: Type THHN/THWN-2, single conductors in raceway.
- G. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

### 3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

### 3.4 INSTALLATION AND ARRANGEMENT OF MC CABLES

- A. Bends in metal clad cable shall be made so that the cable will not be damaged. The radius of the curve of the inner edge of a bend shall not be less than 7 times the diameter of the metallic sheath.
- B. Each branch circuit shall have its own neutral conductor from the branch circuit load back to the circuit breaker panelboard. Shared neutral conductors shall not be installed.
- C. Fittings used for connecting metal clad cable to boxes, light fixtures or other equipment shall be UL listed and identified for such use.
- D. Cable preparation for installation of fittings shall follow manufacturer's instructions.
- E. The cable end shall be cleanly cut with metal clad cable rotary cutting tool to ensure flush seating of the cable into the fitting. Fitting securement screws shall be properly torqued.
- F. Run parallel with walls or structural elements. Vertical runs shall be plumb; horizontal runs level and parallel with structure, as appropriate. Groups shall be racked together neatly with both straight runs and bends parallel and uniformly spaced.
- G. Metal clad cables shall be securely fastened in place at intervals of not more than six feet, with suitable clamps or fasteners of approved type, and vertical runs shall be properly supported to present a secure installation.
- H. Metal clad cable installed parallel to framing members, such as studs, joist, or rafters, shall be supported so that the nearest outside surface of the cable is not less than 1-1/4 inches from the nearest edge of the framing member. Where this distance cannot be maintained, the cable shall be protected by a steel plate, sleeve, or equivalent that is at least 1/16-inch thick.
- I. Maintain at least 6-inch clearance between metal clad cables and other piping systems. Maintain 12-inch clearance between metal clad cables and heat sources such as flues, steam pipes, and heating appliances.
- J. No metal clad cable shall be fastened to other conduits or pipes or installed so as to prevent the ready removal of other pipes or ducts for repairs.
- K. Individual metal clad cables hung from roof structure or structural ceiling shall be supported by split-ring hangers and wrought-iron hanger rods. Where 3 or more metal clad cables are suspended from the ceiling in parallel runs, use steel channels, Unistrut or equal, hung from 1/2-inch rods to support the cables. The cables on these channels shall be held in place with metal clad cable clamps designed for the particular channel that is used.

- L. Metal clad cable shall be supported immediately on each side of a bend and not more than 1 foot from an enclosure where a run of metal clad cable ends.

### 3.5 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least **6 inches** of slack.
- D. The use of split-bolt clamps will be permitted in wireways at service entrance only. Torque to 55 foot-pounds or as recommended by manufacturer.

### 3.6 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

### 3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

### 3.8 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

### 3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
  2. Perform each of the following visual and electrical tests:
    - a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
    - b. Inspect compression-applied connectors for correct cable match and indentation.
    - c. Inspect for correct identification.
    - d. Inspect cable jacket and condition.
- B. Prepare test and inspection reports to record the following:
1. Procedures used.
  2. Results that comply with requirements.
  3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

**END OF SECTION**

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## **SECTION 26 05 26**

### **GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for telecommunications bonding infrastructure.

##### **1.2 SUMMARY**

- A. Section includes grounding and bonding systems and equipment, plus the following special applications:
  - 1. Underground distribution grounding.
  - 2. Ground bonding common with lightning protection system.
  - 3. Foundation steel electrodes.

##### **1.3 SUBMITTALS**

- A. Provide product data for each type of product indicated in Section 260502 – "Shop Drawings".

##### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For grounding to include in operation, and maintenance manuals.
  - 1. In addition to items specified in Section 260500 "General Provisions - Electrical," include the following:
    - a. Plans showing as-built, dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
      - 1) Test wells.
      - 2) Ground rods.
      - 3) Ground rings.
      - 4) Grounding arrangements and connections for separately derived systems.

- b. Instructions for periodic testing and inspection of grounding features at **test wells, ground rings**, and/or **grounding connections for separately derived systems** based on **NETA MTS**.
  - 1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
  - 2) Include recommended testing intervals.

## **PART 2 - PRODUCTS:**

### 2.1 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

### 2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products from one of the following or approved equal:
  - 1. Burndy
  - 2. Eaton B-Line
  - 3. Erico
  - 4. Harger
  - 5. Lyncole
  - 6. Panduit
  - 7. Thomas & Betts

### 2.3 CONDUCTORS

- A. Insulated Conductors: **Copper** wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
  - 1. Solid Conductors: ASTM B 3.
  - 2. Stranded Conductors: ASTM B 8.
  - 3. Tinned Conductors: ASTM B 33.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, minimum **1/4 by 4 inches** in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Busbar length shall be sized to accommodate initial conductor installation plus a 50% growth factor.

Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

## 2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Irreversible Compression Cable Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.
- D. Bus-Bar Connectors: Cast silicon bronze, solderless irreversible compression-type wire terminals, mechanical connector, long-barrel, two-bolt connection to ground bus bar.
- E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- F. Cable-to-Cable Connectors: Irreversible Compression type, copper or copper alloy.
- G. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.
- H. Conduit Hubs: Mechanical type, terminal with threaded hub.
- I. Ground Rod Clamps: Heavy-Duty Mechanical type, copper or copper alloy, terminal with hex head bolt.
- J. Lay-in Lug Connector: Heavy-Duty Mechanical type, copper terminal with set screw.
- K. Straps: Solid copper, copper lugs. Rated for 600 A.
- L. U-Bolt Clamps: Heavy-Duty Mechanical type, copper or copper alloy.
- M. Water Pipe Clamps: Heavy-Duty Mechanical type, high strength silicon bronze, two-piece saddle type with stainless steel bolts.

## 2.5 GROUNDING ELECTRODES

- A. Ground Rods: 10 mil pure electrolytic copper coating with molecular bond to high strength steel core; **3/4 inch by 10 feet**.
- B. Chemical-Enhanced Grounding Electrodes: Self-contained, maintenance free system consisting of a 10-foot copper tube with drilled holes, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.

1. Termination: Factory-attached No. 4/0 AWG copper conductor at least 48 inches long.
  2. Backfill Material: Electrode manufacturer's recommended material.
- C. Enhanced Composite Backfill: Electrically conductive, environmentally-safe, maintenance free backfill material with neutral PH properties that creates a stable, non-corrosive, low resistance connection between a grounding electrode and earth
- D. Test Well: Lightweight polymer concrete, Tier 15 rated, non-slip cover, suitable for non-deliberate incidental traffic.

### **PART 3 - EXECUTION:**

#### **3.1 APPLICATIONS**

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned copper conductor, No. 2 AWG minimum unless otherwise indicated.
1. Bury at least 24 inches below grade or below the frost line depth, whichever is greater.
- C. Grounding Bus: Install in electrical rooms housing service equipment, and elsewhere as indicated, to provide a common connection point for individual grounding electrode conductors and bonding jumpers.
1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
  2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
  3. Provide green laminated plastic nameplate with 1/2" high white letters indicating function of ground bus (i.e. "Service Ground Bus").
- D. Conductor Terminations and Connections: Install in accessible locations except at underground and concrete encased electrodes. Tighten connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torqueing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.
1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
  2. Underground and Exposed Exterior Connections: Exothermic welded connectors except at test wells and as otherwise indicated.
  3. Connections to Ground Rods at Test Wells: Bolted connectors.
  4. Connections to Structural Steel: Exothermic welded connectors.

5. Connections to Aboveground Cable: Irreversible Compression connectors.

### 3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses and a supply side bonding jumper between the utility transformer enclosure and the enclosure of the service entrance equipment

### 3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Transformers: Provide grounding in accordance with the NEC and the following:
  1. System Bonding Jumper (SBJ): Install at the source enclosure between the grounded terminal (neutral) and the equipment grounding terminal.
  2. Supply Side Bonding Jumper (SSBJ): Install wire type SSBJ to bond the source enclosure to the enclosure at the first disconnect or overcurrent protective device.
  3. Grounding Electrode Conductor (GEC): Install at the source enclosure from the SBJ connection point to the building grounding electrode system.
  4. Bonding Jumpers: Where the metal water piping and/or the metal structural steel building frame in the area served by the separately derived system are not used as a grounding electrode, provide bonding jumper to the GEC connection point at the source enclosure.
  5. Equipment Grounding Conductor (EGC): Bond the EGC of the primary feeder to the equipment grounding terminal.
- B. Generators: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator in accordance with the generator manufacturer's recommendations. If the grounded neutral conductor is switched at the transfer switch, provide a main bonding jumper between the grounded terminal (neutral) and the equipment grounding terminal.

### 3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements for utility equipment.
- B. Exterior Pad-Mounted Equipment: Install a minimum of two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with equipment by connecting them to underground grounding conductors and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

### 3.5 EQUIPMENT GROUNDING AND BONDING

- A. Equipment Grounding Conductors: Install insulated equipment grounding conductors with all feeders and branch circuits. Provide conductors of the same wire/cable type as the ungrounded current carrying conductors. Conductors not exceeding No. 8 AWG in size shall use green colored insulation. Conductors larger than No. 6 AWG shall be identified with 4-inch green tape at each termination and at all junction and pull boxes.
- B. Where ungrounded conductor sizes are increased to minimize voltage drop, grounding conductor sizes shall be increased in the proper proportion.
- C. All circuits shall have a dedicated equipment grounding conductor unless noted otherwise.
- D. Provide an equipment grounding conductor to each outlet on circuits protected by a GFCI circuit breaker.
- E. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- F. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

### 3.6 INSTALLATION

- A. Grounding Electrode Conductors and Bonding Jumpers: Securely fasten and route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
  - 1. Route conductors to maintain a downward or horizontal direction to ground with a minimum bend radius of 8-inches.
  - 2. Protection: Above grade conductors No 6 AWG or larger exposed to physical damage and all conductors smaller than no. 6 AWG shall be installed in schedule 40 PVC conduit. Where metallic conduit is required, bond both conduits ends to the electrode or ground conductor as close to the openings as possible with a full-size conductor to create an electrically parallel path.
  - 3. Clearance: Maintain a minimum separation of 2-inches from open telecommunications cable groups.
- B. Bonding for Lightning Protection Systems: Where lightning protection systems are installed comply with NFPA70, NFPA 780, and UL 96 for bonding the lightning protection system ground terminals with the building grounding electrode system.

1. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor.
  2. Conductors and electrodes used for grounding the lightning protection system shall not be used in place of the grounding electrodes required by this specification and section 250.50 of NFPA 70.
- C. Ground Rods: Drive rods until tops are 12 inches below finished floor or final grade unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
  2. Use exothermic welds for all below-grade connections.
  3. For grounding electrode system, install at least **three** rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Chemical Enhanced Grounding Electrodes: In areas with high soil resistivity, such as rocky or sandy soils, or where ground rod depth cannot be achieved, provide chemical enhanced electrodes and/or enhanced backfill material to achieve the ground resistance indicated. Install in accordance with electrode manufacturer's recommendations.
- E. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes shall be at least 12 inches deep, with cover.
1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
  2. Install at each chemical enhanced electrode.
- F. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
  2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
  3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- G. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main

- water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
  3. Other Metal Piping: Bond each aboveground portion of metal piping systems, including gas piping, downstream from its equipment shutoff valve in an accessible location.
  4. Underground portions of natural gas, flammable gas, or liquid fuel piping shall not be used as grounding electrodes.
- H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.
1. Where the building's steel frame is made discontinuous by masonry breaks or expansion joints, provide an accessible fully sized bare copper jumper with exothermic weld connections to bond steel section together. The installation of the bonding jumpers shall be reviewed by the Engineer before covering.
- I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each **steel column indicated**, extending around the perimeter of **building**.
1. Install tinned-copper conductor not less than **No. 2/0** AWG for ground ring and for taps to building steel.
  2. Bury ground ring not less than **60 inches** from building's drip line.
- J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of **20 feet** of bare copper conductor not smaller than **No. 4** AWG.
1. If concrete foundation is less than **20 feet** long, coil excess conductor within base of foundation.
  2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts using exothermic weld connections. Extend grounding conductor below grade and connect to building's ground ring or to grounding electrode external to concrete.
- K. Exothermic Welded Connections: Provide in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.
1. An electronic ignition system shall be used and weld metal shall be a self-contained, sealed system with a bi-metallic fuse to start the reaction.
  2. Comply with AWS Standards for procedures, appearance, and quality of welds; and methods used in correcting welding work.
- L. Connections at Dissimilar Metals: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Clean surfaces and apply anti-oxidant compound prior to installation of connections.
2. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
3. Make connections with clean, bare metal at points of contact.
4. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
5. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

### 3.7 FIELD QUALITY CONTROL

- A. Buried or concealed grounding electrode systems shall be accepted by Engineer/Owner Representative before backfilling or covering.
- B. Perform the following tests and inspections:
  1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
  2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
  3. Ground Resistance Test: Test completed grounding electrode system at service disconnect enclosure grounding terminal and at ground test wells using a manufacturer calibrated and certified ground resistance tester.
    - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    - b. Perform tests using 3-point fall-of-potential method according to IEEE 81.
    - c. Disconnect and isolate the grounding electrode conductor from the electrical system before testing.
    - d. Install outer test probe outside the sphere of influence of the grounding electrode system. This value is typically 10 times the size of the grounding electrode system.
    - e. Install inner test probe at 10 equally spaced intervals, in a straight line between the grounding electrode system connection and the outer test probe and note the resistance reading at each location.
    - f. The resistance measurements taken from the flat part of the curve shall be averaged to determine the grounding electrode system resistance to earth.
    - g. If large variations are noted in the resistance measurements, the outer test probe should be relocated further from grounding electrode system (outside its sphere of influence) to achieve some degree of flatness on the resistance curve.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include test probe locations, observations of weather, and other phenomena that may affect test results. Describe measures taken to improve test results.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports and submit to Engineer for review.
- E. Excessive Ground Resistance: If resistance to ground exceeds 5-ohms, notify Engineer promptly and include recommendations to reduce ground resistance. If deemed necessary by the Engineer, additional electrodes shall be placed and the measurement process repeated until the desired ground potential achieved.

**END OF SECTION**

## **SECTION 26 05 29**

### **HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Slotted support systems.
  - 2. Conduit and cable support devices.
  - 3. Support for conductors in vertical conduit.
  - 4. Structural steel for fabricated supports and restraints.
  - 5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
  - 6. Fabricated metal equipment support assemblies.

##### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
    - a. Slotted support systems, hardware, and accessories.
    - b. Clamps.
    - c. Hangers.
    - d. Sockets.
    - e. Eye nuts.
    - f. Fasteners.
    - g. Anchors.
    - h. Saddles.
    - i. Brackets.
  - 2. Include rated capacities and furnished specialties and accessories.

#### 1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
  - 1. AWS D1.1/D1.1M.
  - 2. AWS D1.2/D1.2M.

### **PART 2 - PRODUCTS:**

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional, as defined in Section 014000 "Quality Requirements," to design support systems and fabricated support assemblies.

#### 2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch- diameter holes at a maximum of 8 inches o.c. in at least one surface.
  - 1. Subject to compliance with requirements, provide products from one of the following or an approved equal:
    - a. B-Line
    - b. Unistrut
    - c. Kindorf
  - 2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
  - 3. Material for Channel, Fittings, and Accessories: Galvanized steel.
  - 4. Channel Width: Selected for applicable load criteria with a minimum of 1-5/8-inch depth.
  - 5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
- B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel with minimum 20 threads per inch.

F. Die Cast fittings are not permitted for supports.

## 2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

## **PART 3 - EXECUTION:**

### 3.1 APPLICATION

- A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
1. NECA 1.
  2. NECA 101
  3. NECA 102.
  4. NECA 105.
- B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports where acceptable to the local AHJ.

### 3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
  1. To Wood: Fasten with lag screws or through bolts.
  2. To New Concrete: Bolt to concrete inserts.
  3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
  4. To Existing Concrete: Expansion anchor fasteners.
  5. Where approved by structural engineer, instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
  6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts or Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
  7. To Light Steel: Sheet metal screws.
  8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.
- E. Install riser support clamps at each floor level penetration, or as otherwise required. Provide conduit cable support clamps within properly sized and anchored junction box for vertical conductor runs as required
- F. Where required by codes or other standards, provide spacers behind mounting clamps to space conduits off walls.

- G. All electrical raceways and devices shall be hung independently from the building structure with U.L. listed and approved materials. Hangers and supports depending on the support systems of other trades work shall not be permitted, except with specific approval in writing from the Engineer.
- H. The use of tie wire or perforated metal tape for support or fastening of any raceway system is prohibited.
- I. No raceway or device shall be installed on acoustic tile ceiling tees, or in any location that will impair the functioning, access or code-required clearances for any equipment or system.
- J. Welding directly on conduit or fittings is not permitted.

### 3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- B. Field Welding: Comply with AWS D1.1/D1.1M.

### 3.4 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

### END OF SECTION

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## **SECTION 26 05 33**

### **RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS**

#### **PART 1 - GENERAL:**

#### **PART 2 - RELATED DOCUMENTS**

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

#### **2.2 SUMMARY**

- A. Section Includes:
  - 1. Metal conduits and fittings.
  - 2. Nonmetallic conduits and fittings.
  - 3. Metal wireways and auxiliary gutters.
  - 4. Surface raceways.
  - 5. Boxes, enclosures, and cabinets.

#### **2.3 DEFINITIONS**

- A. ARC: Aluminum rigid conduit.
- B. EMT: Electrical Metallic Tubing
- C. GRC: Galvanized rigid steel conduit.
- D. IMC: Intermediate metal conduit.

#### **2.4 ACTION SUBMITTALS**

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

**PART 3 - PRODUCTS:**

**3.1 METAL CONDUITS AND FITTINGS**

**A. Metal Conduit:**

1. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. GRC: Comply with ANSI C80.1 and UL 6.
3. ARC: Comply with ANSI C80.5 and UL 6A.
4. IMC: Comply with ANSI C80.6 and UL 1242.
5. PVC-Coated Steel Conduit: PVC-coated **rigid steel conduit**.
  - a. Comply with NEMA RN 1.
  - b. Coating Thickness: 0.040 inch , minimum.
6. EMT: Comply with ANSI C80.3 and UL 797.
7. FMC: Comply with UL 1; **zinc-coated steel**.
8. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

**B. Metal Fittings:**

1. Comply with NEMA FB 1 and UL 514B.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Fittings, General: Listed and labeled for type of conduit, location, and use. Gray iron, malleable iron or heavy copper-free cast aluminum.
4. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
5. Fittings for EMT:
  - a. Material: **Steel**.
  - b. Type: **compression**.
6. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
7. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

- C. Joint Compound for IMC, GRC, or ARC:** Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

**3.2 NONMETALLIC CONDUITS AND FITTINGS**

**A. Nonmetallic Conduit:**

1. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. RNC: **Type EPC-40-PVC** and Type EPC-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

B. Nonmetallic Fittings:

1. Fittings, General: Listed and labeled for type of conduit, location, and use.
2. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
  - a. Fittings for LFNC: Comply with UL 514B.
3. Solvents and Adhesives: As recommended by conduit manufacturer.

3.3 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Description: Sheet metal, complying with UL 870 and NEMA 250, sized according to NFPA 70.
  1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- C. Wireway Covers: **Hinged type** for runs and **screw-cover type** for fittings unless otherwise indicated.
- D. Finish: Manufacturer's standard enamel finish.

3.4 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Corrosion resistant galvanized steel or aluminum with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect. Finishes shall be suitable for field painting.

3.5 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

- B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, **ferrous alloy**, Type FD, with gasketed cover.
- D. Luminaire Outlet Boxes: Outlet boxes designed for attachment of luminaires shall be listed and marked for the maximum allowable weight with at least a 2x safety factor for the anticipated fixture weight.
- E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1, constructed of code gauge, galvanized steel with sides formed and corner seams riveted or welded before galvanizing
- F. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, **cast aluminum** with gasketed cover.
- G. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- H. Device Box Dimensions: minimum 4 inches square by 2-1/8 inches deep unless noted otherwise.
- I. Gangable boxes **are prohibited**.
- J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250 with continuous-hinge cover with flush latch unless otherwise indicated.
  - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

### 3.6 MULTI-SERVICE FLOOR BOXES AND POKE-THROUGHS

- A. Description: Recessed multi-gang outlet with devices capable of supplying power, data, voice, and AV services.
- B. Manufacturers: Subject to compliance with requirements, provide product indicated on drawings or approved equal by one of the following:
  - 1. Wiremold
  - 2. Hubbell
  - 3. FSR
- C. UL 514A Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Floor Boxes and Poke-Thru Assemblies
  - 1. Material: Cast metal or sheet metal with finished interior
  - 2. Type: Fully adjustable before and after floor installation.

3. Shape: Rectangular or Round
4. Designed for use with industry standard wall plates, devices, and modular inserts.
5. Cover: Hinged, Gasketed, Die-cast, powder coated aluminum suitable for multiple floor surfaces. Provide covers with spring-loaded self-closing slide egress doors to reduce egress opening when cables are exiting and reduce trip hazards.
6. Painted with fusion-bonded epoxy where used in on-grade floor applications.
7. Classified for fire resistance up to 2 hours where used in rated floors.
8. Evaluated by UL to meet U.S. safety standards for scrub water exclusion.

E. Refer to Division 27 for low voltage cabling and connector requirements.

#### **PART 4 - EXECUTION:**

##### **4.1 RACEWAY APPLICATION**

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: **GRC**.
2. Underground or Underslab Conduit: RNC, **Type EPC-40-PVC** in concrete encasement or **Type EPC-80-PVC**, unless noted otherwise on the drawings.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): **LFMC**.
4. Boxes and Enclosures, Aboveground: NEMA 250, **Type 3R**.
5. RNC shall not be installed in environmental air plenums or cast into above grade concrete slabs. It shall not be run in interior locations, except with special permission from the Engineer for use in corrosive environments, and then only if protected from physical damage.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: **EMT**.
  - a. Exposed areas above 6 ft AFF shall not be considered subject to physical damage unless noted otherwise on drawings.
2. Exposed and Subject to Physical Damage: IMC or **GRC**. Raceway locations include the following:
  - a. Loading dock.
  - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
  - c. Mechanical rooms.
  - d. Gymnasiums.
  - e. Kitchens and Food Service Areas
3. Concealed in Ceilings and Interior Walls and Partitions: **EMT**.

4. Connection to Light Fixtures or Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
  5. Damp or Wet Locations: **IMC**.
  6. For conductors rated over 600V: GRC
  7. Hazardous Locations: IMC or GRC
  8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 **stainless steel** in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Raceway Size: **3/4-inch** trade size unless noted otherwise on the drawings.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
  2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
  3. EMT: Use **compression, steel** fittings. Comply with NEMA FB 2.10.
  4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth or where prolonged contact with construction materials will degrade the aluminum.
- F. Do not install nonmetallic conduit where ambient temperature or operating temperature of the conductors exceeds the rating of the raceway.
- G. Install raceways and fittings in a manner to avoid use of dissimilar metals that would result in galvanic action corrosion.

#### 4.2 INSTALLATION

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- C. Comply with utility company requirements for installations supporting utility company provided conductors.
- D. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

- E. Unless using GRC or IMC, do not fasten conduits within 1-1/2 inches of the bottom side of a metal deck roof.
- F. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- G. Complete raceway installation before starting conductor installation.
- H. Underground RNC shall be transitioned to GRC at all ells and stub-ups through concrete slabs. Arrange stub-ups so curved portions of bends are not visible above finished slab. Rigid steel conduit shall be used to a minimum height of 6" above finished floor where it may be transitioned to EMT unless rigid steel is required for damage protection.
- I. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.
- J. Conduit runs shall not exceed 85-feet without junction box or pull point.
- K. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.
- L. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines, walls, and structural members.
- M. Level and square raceway runs, and install at proper elevations and required heights. Hold tight to structure wherever possible, to maximize available space and not restrict other trades.
- N. Support conduit within 12 inches of enclosures to which attached.
- O. Raceways shall not be installed below or embedded in concrete slabs unless approved by architect and engineer:
  - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
  - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
  - 3. Arrange raceways to keep a minimum of **2 inches** of concrete cover in all directions.
  - 4. Do not embed thread-less fittings in concrete unless specifically approved by Architect for each specific location.
- P. Stub-Ups to Above Recessed Ceilings:
  - 1. Use EMT, IMC, or RMC for raceways.

2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- Q. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- R. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
- S. All EMT terminations at junction boxes, panels, etc. shall be made with case hardened locknuts and appropriate fittings, with insulated throat liners. Insulating terminations shall be manufactured as a single unit. The use of split sleeve insulators are not permitted.
- T. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install heavy fiber insulated throat metal grounding bushings on all branch, feeder, and service conduits and bond to enclosures with appropriately sized jumpers. All threaded fittings shall have tapered thread with all burrs removed, reamed ends and cutting oil wiped clean and engaged seven full threads.
- U. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- V. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- W. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- X. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of secured slack at each end of pull wire. Cap and seal underground raceways designated as spare above grade alongside raceways in use.
- Y. Install wireways using manufacturer's recommended hangers and hardware as to allow unobstructed access to wireway interior.
- Z. Surface Raceways:
1. Surface metal raceways shall be provided where indicated on drawings or where concealed raceways are not possible.
  2. Surface raceways shall be sized for the number of devices and conductors indicated.
  3. Install surface raceway with a minimum 2-inch radius control at bend points.
  4. Secure surface raceway with two hole straps at intervals not exceeding 24 inches and with no less than two supports per straight raceway section and within 6 inches of ends and corners. Support surface raceway according to

- manufacturer's written instructions. Tape and glue are not acceptable support methods.
5. Surface metal raceways and all components and fittings shall be furnished by a single manufacturer, wherever practical. All trim and cover fittings, flush feed boxes, splices, outlet fittings, etc., necessary for a complete installation shall be provided by the installing Contractor.
- AA. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
- BB. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  2. Where an underground service raceway enters a building or structure.
  3. Conduit extending from interior to exterior of building.
  4. Conduit extending into pressurized duct and equipment.
  5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
  6. Where otherwise required by NFPA 70.
- CC. Conduit shall be installed in such a manner so as to ensure against collection of trapped condensation. All runs of conduit shall be arranged so as to be devoid of traps. Trapped conduit runs shall be provided with manufactured drains at low points.
- DD. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- EE. Expansion-Joint Fittings:
1. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
  2. Install expansion fittings at all locations where conduits cross building or structure expansion joints. Provide copper ground bonding jumpers across expansion fittings.
  3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- FF. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of **72 inches** of flexible conduit for recessed and semi-recessed luminaires, and **36-inches** for all other equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. All flexible metal conduit shall be installed as a single piece with clamp-on insulated throat connectors designed for the purpose.
  2. Provide strain relief fittings where subject to vibration
  3. An equipment grounding conductor or bonding jumper shall be used at all flexible conduit installations.
  4. Use LFMC in damp or wet locations subject to physical damage.
- GG. Outlet boxes shall be installed recessed in building construction with face flush with finished surfaces unless noted otherwise.
- HH. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to **center** of box unless otherwise indicated.
- II. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box. Do Not Split The Mortar Joint
- JJ. For outlets supporting suspended luminaires, appliances, or wiring devices, provide minimum 3/4-inch rigid conduit pendant. Outlet boxes shall be malleable iron, provided with self-aligning covers with swivel ball joint and No. 14 gauge steel locking ring. Provide safety chain between building structure and ballast housing of light fixtures for all fixtures, appliances or devices greater than 10 lbs. weight. Fixtures shall be installed plumb and level.
- KK. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- LL. Locate boxes so that cover or plate will not span different building finishes.
- MM. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- NN. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- OO. Set metal floor boxes level and flush with finished floor surface unless noted otherwise.
- PP. All cabinets and boxes for NEMA 1 and 1A application shall be provided with knockouts, as necessary, or shall be cut in the field by approved cutting tools which will provide a clean, symmetrically cut opening.
- QQ. Raceways installed in exterior locations shall receive one coat of primer, two coats finish paint after preparation of galvanizing, color selected by Architect. Exposed raceways in painted interior areas shall be similarly painted.
- RR. Provide separate raceway systems including conduit, pull boxes, etc for normal power systems and each emergency power branch.

4.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

4.4 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

4.5 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
  - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

**END OF SECTION**

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## **SECTION 260543**

### **UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
  - 2. Rigid nonmetallic duct.
  - 3. Flexible nonmetallic duct.
  - 4. Duct accessories.
  - 5. Precast concrete handholes.
  - 6. Polymer concrete handholes and boxes with polymer concrete cover.
  - 7. Fiberglass handholes and boxes with polymer concrete cover.
  - 8. Fiberglass handholes and boxes.
  - 9. High-density plastic boxes.
  - 10. Precast manholes.
  - 11. Cast-in-place manholes.
  - 12. Utility structure accessories.

##### **1.3 DEFINITIONS**

- A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.
- B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.
- C. Duct Bank:
  - 1. Two or more ducts installed in parallel, with or without additional casing materials.
  - 2. Multiple duct banks.
- D. GRC: Galvanized rigid (steel) conduit.

- E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1. Include duct-bank materials, including spacers and miscellaneous components.
2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for manholes, handholes, boxes[, and **other utility structures**].
4. Include underground-line warning tape.
5. Include warning planks.

- B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:
  - a. Include plans, elevations, sections, details, attachments to other work, and accessories.
  - b. Include duct entry provisions, including locations and duct sizes.
  - c. Include reinforcement details.
  - d. Include frame and cover design and manhole chimneys.
  - e. Include [**ladder**] [**step**] details.
  - f. Include grounding details.
  - g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
  - h. Include joint details.
2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:
  - a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
  - b. Include duct entry provisions, including locations and duct sizes.
  - c. Include cover design.
  - d. Include grounding details.
  - e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

- C. Sustainable Design Submittals:

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: For duct and duct bank. Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
  2. Drawings shall be signed and sealed by a qualified professional engineer.
- B. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.
- C. Product Certificates: For concrete and steel used in precast concrete **[manholes]** **[and]** **[handholes]**, as required by ASTM C 858.
- D. Source quality-control reports.
- E. Field quality-control reports.

#### 1.6 MAINTENANCE MATERIALS SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Furnish cable-support stanchions, arms, **[insulators,]** **<Insert accessories and specialties>** and associated fasteners in quantities equal to **[5]** **<Insert number>** percent of quantity of each item installed.

#### 1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

#### 1.8 FIELD CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:
1. Notify **[Architect]** **[Construction Manager]** **[Owner]** no fewer than **[two]** **<Insert number>** days in advance of proposed interruption of electrical service.
  2. Do not proceed with interruption of electrical service without **[Architect's]** **[Construction Manager's]** **[Owner's]** written permission.
- B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.
- C. Ground Water: Assume ground-water level is **[36 inches (900 mm)]** **<Insert dimension>** below ground surface unless a higher water table is noted on Drawings.

## **PART 2 - PRODUCTS**

### **2.1 METAL CONDUIT AND FITTINGS**

- A. GRC: Comply with ANSI C80.1 and UL 6.
- B. Coated Steel Conduit: PVC-coated **[GRC]** **[IMC]**.
  - 1. Comply with NEMA RN 1.
  - 2. Coating Thickness: **0.040 inch (1 mm)**, minimum.
- C. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- D. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

### **2.2 RIGID NONMETALLIC DUCT**

- A. Underground Plastic Utilities Duct: **[Type EPC-80-PVC]** **[and]** **[Type EPC-40-PVC]** RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.
- B. Underground Plastic Utilities Duct: **[Type DB-60 PVC]** **[and]** **[Type DB-120 PVC]** RNC, complying with NEMA TC 6 & 8 and ASTM F 512 for direct burial, with matching fittings complying with NEMA TC 9 by same manufacturer as duct.
- C. Underground Plastic Utilities Duct: Type EB-20 PVC RNC, complying with NEMA TC 6 & 8, ASTM F 512, and UL 651, with matching fittings complying with NEMA TC 9 by same manufacturer as duct.
- D. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- E. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
- F. Solvents and Adhesives: As recommended by conduit manufacturer.
  - 1. [<Double click to insert sustainable design text for VOC limits for exterior ducts.>](#)

### **2.3 FLEXIBLE NONMETALLIC DUCTS**

- A. HDPE Duct: **[Type EPEC-40 HDPE]** **[Type EPEC-80 HDPE]**, complying with NEMA TC 7 and UL 651A.
  - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
  - 2. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

## 2.4 DUCT ACCESSORIES

- A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.
  - 1. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."
- C. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 75 mm) in size, manufactured from 6000-psi (41-MPa) concrete.
  - 1. Color: Red dye added to concrete during batching.
  - 2. Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.

## 2.5 PRECAST CONCRETE HANDHOLES AND BOXES

- A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
- B. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- C. Comply with ASTM C 858 for design and manufacturing processes.
- D. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
- E. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
- F. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
  - 1. Cover Hinges: Concealed, with hold-open ratchet assembly.
  - 2. Cover Handle: Recessed.
- G. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.
  - 1. Cover Hinges: Concealed, with hold-open ratchet assembly.
  - 2. Cover Handle: Recessed.
- H. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

- I. Cover Legend: Molded lettering, ["**ELECTRIC.**"] [as indicated for each service.] <Insert legend.>
  - J. Configuration: Units shall be designed for flush burial and have [open] [closed] [integral closed] bottom unless otherwise indicated.
  - K. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
    - 1. Extension shall provide increased depth of [12 inches (300 mm)] <Insert dimension>.
    - 2. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.
  - L. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.
  - M. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
    - 1. [Splayed] [Center window] location.
    - 2. Knockout panels shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
    - 3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
    - 4. Knockout panels shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
    - 5. Knockout panels shall be 1-1/2 to 2 inches (38 to 50 mm) thick.
  - N. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
    - 1. Type and size shall match fittings to duct to be terminated.
    - 2. Fittings shall align with elevations of approaching duct and be located near interior corners of handholes to facilitate racking of cable.
  - O. Handholes [12 inches wide by 24 inches long (300 mm wide by 600 mm long)] <Insert dimensions> and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.
- 2.6 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER
- A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
  - B. <[Double click here to find, evaluate, and insert list of manufacturers and products.](#)>

- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: **[Gray]** **[Green]**.
- E. Configuration: Units shall be designed for flush burial and have **[open]** **[closed]** **[integral closed]** bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, **["ELECTRIC."]** **[as indicated for each service.]** **<Insert legend.>**
- I. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
- J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- K. Handholes **[12 inches wide by 24 inches long (300 mm wide by 600 mm long)]** **<Insert dimensions>** and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.7 FIBERGLASS HANDHOLES AND BOXES WITH POLYMER CONCRETE FRAME AND COVER

- A. Description: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
- B. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: **[Gray]** **[Green]**.
- E. Configuration: Units shall be designed for flush burial and have **[open]** **[closed]** **[integral closed]** bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, **["ELECTRIC."]** **[as indicated for each service.]** **<Insert legend.>**

- I. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
- J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- K. Handholes [**12 inches wide by 24 inches long** (300 mm wide by 600 mm long)] <Insert dimensions> and larger shall have factory-installed inserts for cable racks and pulling-in irons.

## 2.8 FIBERGLASS HANDHOLES AND BOXES

- A. Description: Molded of fiberglass-reinforced polyester resin, with covers made of [polymer concrete] [reinforced concrete] [cast iron] [hot-dip galvanized-steel diamond plate] [fiberglass].
- B. <[Double click here to find, evaluate, and insert list of manufacturers and products.](#)>
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: [Gray] [Green].
- E. Configuration: Units shall be designed for flush burial and have [open] [closed] [integral closed] bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, ["ELECTRIC."] [as indicated for each service.] <Insert legend.>
- I. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
- J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- K. Handholes [**12 inches wide by 24 inches long** (300 mm wide by 600 mm long)] <Insert dimensions> and larger shall have factory-installed inserts for cable racks and pulling-in irons.

## 2.9 HIGH-DENSITY PLASTIC BOXES

- A. Description: Injection molded of HDPE or copolymer-polypropylene. Cover shall be made of **[polymer concrete] [hot-dip galvanized-steel diamond plate] [plastic]**.
- B. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: **[Gray] [Green]**.
- E. Configuration: Units shall be designed for flush burial and have **[open] [closed] [integral closed]** bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, **["ELECTRIC."] [as indicated for each service.] <Insert legend.>**
- I. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
- J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- K. Handholes **[12 inches wide by 24 inches long (300 mm wide by 600 mm long)] <Insert dimensions>** and larger shall have factory-installed inserts for cable racks and pulling-in irons.

## 2.10 PRECAST MANHOLES

- A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.
- B. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- C. Comply with ASTM C 858.
- D. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.
- E. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional **12 inches (300 mm)** vertically and horizontally to accommodate alignment variations.

1. **[Splayed] [Center window]** location.
  2. Knockout panels shall be located no less than **6 inches (150 mm)** from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
  3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
  4. Knockout panel shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
  5. Knockout panels shall be **1-1/2 to 2 inches (38 to 50 mm)** thick.
- F. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
1. Type and size shall match fittings to duct to be terminated.
  2. Fittings shall align with elevations of approaching duct and be located near interior corners of manholes to facilitate racking of cable.
- G. Ground Rod Sleeve: Provide a **3-inch (75-mm)** PVC sleeve in manhole floors **2 inches (50 mm)** from the wall adjacent to, but not underneath, the duct entering the structure.
- H. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

## 2.11 CAST-IN-PLACE MANHOLES

- A. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for duct entrance and sleeve for ground rod.
- B. Materials: Comply with ASTM C 858 and with Section 033000 "Cast-in-Place Concrete."
- C. Structural Design Loading: As specified in "Underground Enclosure Application" Article.

## 2.12 UTILITY STRUCTURE ACCESSORIES

- A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.
- B. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- C. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
  1. Frame and Cover: Weatherproof, **[gray cast iron complying with ASTM A 48/A 48M, Class 30B] [cast aluminum]** with milled cover-to-frame bearing surfaces; diameter, **[26 inches (660 mm)] [29 inches (725 mm)]**.

- a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
  - b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
2. Cover Legend: Cast in. Selected to suit system.
  - a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
  - b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
  - a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.
  - b. Seal joints watertight using preformed plastic or rubber complying with ASTM C 990. Install sealing material according to sealant manufacturers' written instructions.
- D. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.
- E. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.
  1. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.
- F. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- (31-mm-) diameter eye, rated [2500-lbf (11-kN)] <Insert value> minimum tension.
- G. Pulling-in and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
  1. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.
- H. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (31 mm) minimum at base.
  1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.
- I. Ground Rod Sleeve: 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.

- J. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.
- K. Cable Rack Assembly: Steel, [hot-rolled] [hot-dip] galvanized, except insulators.
1. Stanchions: T-section or channel with provisions to connect to other sections or channels to form a continuous unit; 1-1/2 inches (38 mm) in width by nominal 24 inches (600 mm) long; punched with 14 hook holes on 1-1/2-inch (38-mm) centers for cable-arm attachment.
  2. Arms: 1-1/2 inches (38 mm) wide, lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 18 inches (450 mm) with 250-lb (114-kg) minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
  3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.
- L. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
1. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with provisions to connect to other sections to form a continuous unit, with minimum of nine holes for arm attachment.
  2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (500 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.
- M. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- N. Fixed Manhole Ladders: Arranged for attachment to [roof] [or] [wall] [ and floor] of manhole. Ladder and mounting brackets and braces shall be fabricated from [nonconductive, structural-grade, fiberglass-reinforced resin] [hot-dip galvanized steel].
- O. Portable Manhole Ladders: UL-listed, heavy-duty [wood] [fiberglass] specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches (900 mm). [One] <Insert number> required.
- P. Cover Hooks: [Heavy duty, designed for lifts 60 lbf (270 N) and greater] [Light duty, designed for lifts less than 60 lbf (270 N)]. [Two] <Insert number> required.

## 2.13 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.
- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
  - 1. Tests of materials shall be performed by an independent testing agency.
  - 2. Strength tests of complete boxes and covers shall be by an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
  - 3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

## **PART 3 - EXECUTION**

### 3.1 PREPARATION

- A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.
- C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 311000 "Site Clearing."

### 3.2 UNDERGROUND DUCT APPLICATION

- A. Duct for Electrical Cables More Than 600 V: **[Type EPC-80-PVC] [Type EPC-40-PVC] [Type EB-20-PVC]** RNC, concrete-encased unless otherwise indicated.
- B. Duct for Electrical Feeders 600 V and Less: **[Type EPC-80-PVC] [Type EPC-40-PVC] [Type EB-20-PVC]** RNC, concrete-encased unless otherwise indicated.
- C. Duct for Electrical Feeders 600 V and Less: **[Type EPC-80-PVC] [Type EPC-40-PVC]** RNC, direct-buried unless otherwise indicated.
- D. Duct for Electrical Branch Circuits: **[Type EPC-80-PVC] [Type EPC-40-PVC]** RNC, direct-buried unless otherwise indicated.

- E. Bored Underground Duct: **[Type EPEC-40-HDPE] [Type EPEC-80-HDPE]** unless otherwise indicated.
- F. Underground Ducts Crossing **[Paved Paths] [Walks] [and] [Driveways] [Roadways] [and Railroads]**: Type EPC-40 PVC RNC, encased in reinforced concrete.
- G. Stub-ups: Concrete-encased **[RNC] [GRC] [PVC-coated GRC]**.

### 3.3 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less:
  - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, **[H-10] [H-20]** structural load rating.
  - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: **[Precast concrete, AASHTO HB 17, H-20] [Polymer concrete, SCTE 77, Tier 15] [Fiberglass enclosures with polymer concrete frame and cover, SCTE 77, Tier 15] [Fiberglass-reinforced polyester resin, SCTE 77, Tier 15] [High-density plastic, SCTE 77, Tier 15]** structural load rating.
  - 3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: **[Precast concrete, AASHTO HB 17, H-10] [Polymer concrete units, SCTE 77, Tier 8] [Heavy-duty fiberglass units with polymer concrete frame and cover, SCTE 77, Tier 8] [High-density plastic, SCTE 77, Tier 8]** structural load rating.
  - 4. Units Subject to Light-Duty Pedestrian Traffic Only: **[Fiberglass-reinforced polyester resin] [High-density plastic]**, structurally tested according to SCTE 77 with **3000-lbf (13 345-N)** vertical loading.
  - 5. Cover design load shall not exceed the design load of the handhole or box.
- B. Manholes: **[Precast] [or] [cast-in-place]** concrete.
  - 1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
  - 2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

### 3.4 EARTHWORK

- A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restoration: Replace area **[immediately after backfilling is completed] [or] [after construction vehicle traffic in immediate area is complete]**.
- C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

- D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."
- E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 017300 "Execution."

### 3.5 DUCT AND DUCT-BANK INSTALLATION

- A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
- B. Install duct according to NEMA TCB 2.
- C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.
- D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of [48 inches (1200 mm)] [12.5 feet (4 m)] [25 feet (7.5 m)], both horizontally and vertically, at other locations unless otherwise indicated.
  - 1. Duct shall have maximum of two 90 degree bends or the total of all bends shall be no more 180 degrees between pull points.
- E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.
- F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) duct, and vary proportionately for other duct sizes.
  - 1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell, without reducing duct slope and without forming a trap in the line.
  - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install

- an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than **3/4 inch (19 mm)**.
3. Grout end bells into structure walls from both sides to provide watertight entrances.
- H. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately **6 inches (150 mm)** o.c. for **4-inch (100-mm)** duct, and vary proportionately for other duct sizes.
1. Begin change from regular spacing to terminator spacing **10 feet (3 m)** from the terminator, without reducing duct line slope and without forming a trap in the line.
  2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line duct with calculated expansion of more than **3/4 inch (19 mm)**.
- I. Building Wall Penetrations: Make a transition from underground duct to GRC at least **10 feet (3 m)** outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- J. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least **15-psig (1.03-MPa)** hydrostatic pressure.
- K. Pulling Cord: Install **200-lbf- (1000-N-)** test nylon cord in empty ducts.
- L. Concrete-Encased Ducts and Duct Bank:
1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes less than **6 inches (150 mm)** in nominal diameter.
  2. Width: Excavate trench **12 inches (300 mm)** wider than duct on each side.
  3. Width: Excavate trench **3 inches (75 mm)** wider than duct on each side.
  4. Depth: Install so top of duct envelope is at least **24 inches (600 mm)** below finished grade in areas not subject to deliberate traffic, and at least **30 inches (750 mm)** below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
  5. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
  6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than **[four] [five]** spacers per **20 feet (6 m)** of duct. Place spacers within **24 inches (600 mm)** of duct ends. Stagger spacers approximately **6 inches (150 mm)** between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.

7. Minimum Space between Duct: **3 inches (75 mm)** between edge of duct and exterior envelope wall, **2 inches (50 mm)** between ducts for like services, and **4 inches (100 mm)** between power and communications ducts.
8. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
9. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.
  - a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with **3 inches (75 mm)** of concrete.
  - b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of **60 inches (1500 mm)** from edge of base. Install insulated grounding bushings on terminations at equipment.
    - 1) Stub-ups shall be **[flush with] [minimum 4 inches (100 mm)above]** finished floor and minimum **3 inches (75 mm)** from conduit side to edge of slab.
  - c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of **60 inches (1500 mm)** from edge of wall. Install insulated grounding bushings on terminations at equipment.
    - 1) Stub-ups shall be **[flush with] [minimum 4 inches (100 mm)above]** finished floor and no less than **3 inches (75 mm)** from conduit side to edge of slab.
10. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
11. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
12. Concrete Cover: Install a minimum of **3 inches (75 mm)** of concrete cover between edge of duct to exterior envelope wall, **2 inches (50 mm)** between duct of like services, and **4 inches (100 mm)** between power and communications ducts.
13. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
  - a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions, or use other specific measures to prevent expansion-contraction damage.
  - b. If more than one pour is necessary, terminate each pour in a vertical plane and install **3/4-inch (15-mm)** reinforcing-rod dowels extending a minimum of **18 inches (450 mm)** into concrete on both sides of joint near corners of envelope.

14. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

M. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches (150 mm) in nominal diameter.
2. Width: Excavate trench 12 inches (300 mm) wider than duct on each side.
3. Width: Excavate trench 3 inches (75 mm) wider than duct on each side.
4. Depth: Install top of duct at least 36 inches (900 mm) below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than [four] [five] spacers per 20 feet (6 m) of duct. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
8. Install duct with a minimum of 3 inches (75 mm) between ducts for like services and 6 inches (150 mm) between power and communications duct.
9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
10. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.
  - a. Couple RNC duct to GRC with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
  - b. Stub-ups to Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.
    - 1) Stub-ups shall be [flush with] [minimum 4 inches (100 mm) above] finished floor and minimum 3 inches (75 mm) from conduit side to edge of slab.
  - c. Stub-ups to Indoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches (1500 mm) from edge of wall. Install insulated grounding bushings on terminations at equipment.

- 1) Stub-ups shall be [flush with] [minimum 4 inches (100 mm) above] finished floor and no less than 3 inches (75 mm) from conduit side to edge of slab.
11. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches (100 mm) over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.
    - a. Place minimum 3 inches (75 mm) of sand as a bed for duct. Place sand to a minimum of 6 inches (150 mm) above top level of duct.
    - b. Place minimum 6 inches (150 mm) of engineered fill above concrete encasement of duct.
  - N. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried duct, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of duct or duct bank. Provide an additional plank for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional planks 12 inches (300 mm) apart, horizontally.
  - O. Underground-Line Warning Tape: Bury [nonconducting] [conducting] underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inches (300 mm) above all concrete-encased duct and duct banks [and approximately 12 inches (300 mm) below grade]. Align tape parallel to and within 3 inches (75 mm) of centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.
- ### 3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES
- A. Cast-in-Place Manhole Installation:
    1. Finish interior surfaces with a smooth-troweled finish.
    2. Knockouts for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches (38 to 50 mm) thick, arranged as indicated.
    3. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.
  - B. Precast Concrete Handhole and Manhole Installation:
    1. Comply with ASTM C 891 unless otherwise indicated.
    2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.

3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevations:
1. Manhole Roof: Install with rooftop at least 15 inches (375 mm) below finished grade.
  2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
  3. Install handholes with bottom below frost line, <Insert depth of frost line below grade at Project site> below grade.
  4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
  5. Where indicated, cast handhole cover frame integrally with handhole structure.
- D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
- E. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
  2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.
- F. Waterproofing: Apply waterproofing to exterior surfaces of manholes[ **and handholes**] after concrete has cured at least three days. Waterproofing materials and installation are specified in [Section 071353 "Elastomeric Sheet Waterproofing."] [Section 071354 "Thermoplastic Sheet Waterproofing."] <Insert waterproofing Section.> After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.
- G. Dampproofing: Apply dampproofing to exterior surfaces of manholes[ **and handholes**] after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 071113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.
- H. Hardware: Install removable hardware, including pulling eyes, cable stanchions, [and] cable arms, [and insulators], as required for installation and support of cables and conductors and as indicated.
- I. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

- J. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than **3-7/8 inches (97 mm)** for manholes and **2 inches (50 mm)** for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

### 3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from **1/2-inch (12.5-mm)** sieve to **No. 4 (4.75-mm)** sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes **1 inch (25 mm)** above finished grade.
- D. Install handholes and boxes with bottom below frost line, **<Insert depth of frost line below grade at Project site>** below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- F. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in **[asphalt paving] [and] <Insert material>** and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on **[compacted earth] <Insert material>**.
  - 1. Concrete: **3000 psi (20 kPa)**, 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
  - 2. Dimensions: **[10 inches wide by 12 inches deep (250 mm wide by 300 mm deep)] <Insert dimensions>**.

### 3.8 GROUNDING

- A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

### 3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
  - 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum **12-inch-(300-mm-)** long mandrel equal to duct size minus **1/4 inch (6 mm)**. If obstructions are indicated, remove obstructions and retest.
  - 3. Test manhole[ **and handhole**] grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.
- C. Prepare test and inspection reports.

### 3.10 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump.
  - 1. Sweep floor, removing dirt and debris.
  - 2. Remove foreign material.

**END OF SECTION**

## **SECTION 26 05 44**

### **SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
  - 2. Sleeve-seal systems.
  - 3. Grout.

#### **PART 2 - PRODUCTS:**

##### **2.1 SLEEVES**

- A. Wall and Floor Sleeves:
  - 1. Galvanized Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
- B. Sleeves for Rectangular Openings:
  - 1. Material: Galvanized sheet steel.
  - 2. Minimum Metal Thickness:
    - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
    - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

## 2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable. Link Seal system or approved equal.
  - 1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
  - 2. Pressure Plates: Glass reinforced nylon polymer.
  - 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

## 2.3 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

## **PART 3 - EXECUTION:**

### 3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits or Cable Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
  - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
    - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
    - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
  - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
  - 3. Size pipe sleeves to provide a minimum 1/4-inch annular clear space between sleeve and raceway to permit free movement of pipe during expansion and contraction.

4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
  5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level unless noted otherwise. Install sleeves during erection of floors.
  6. Fasten sleeves securely in floors, walls, so that they will not become displaced when concrete is poured or when other construction occurs around them. Take precautions to prevent concrete, plaster or other materials being forced into the space between pipe and sleeve during construction.
- D. Sleeves for Conduits or Cable Penetrating Non-Fire-Rated Gypsum Board Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
  2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units and counter flashing applied in coordination with roofing work.
- F. Exterior-Wall and Floor Penetrations: Install steel pipe sleeves. Size sleeves to allow for manufacturer recommended annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

### 3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

### END OF SECTION

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## **SECTION 260553**

### **IDENTIFICATION FOR ELECTRICAL SYSTEMS**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Color and legend requirements for raceways, conductors, and warning labels and signs.
  - 2. Labels.
  - 3. Bands.
  - 4. Tapes.
  - 5. Tags.
  - 6. Signs.
  - 7. Cable ties.
  - 8. Paint for identification.
  - 9. Fasteners for labels and signs.

##### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

#### **PART 2 - PRODUCTS**

##### **2.1 PERFORMANCE REQUIREMENTS**

- A. Comply with ASME A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Comply with NFPA 70E and Section 260573 "Power Systems Studies" requirements for arc-flash warning labels.
- F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- G. Thermal Movements: Allow for thermal movements from ambient temperatures up to 120-deg F and surface temperatures up to 180-deg F.

## 2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:
  - 1. Black letters on an orange field.
  - 2. Legend: Indicate voltage, system, and circuit designation.
- B. Color-Coding for Phase-and Voltage-Level Identification, 600 V or Less: Use colors listed below for service, feeder, and branch-circuit conductors.
  - 1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
  - 2. Colors for 208/120-V Circuits:
    - a. Phase A: Black.
    - b. Phase B: Red.
    - c. Phase C: Blue.
    - d. Neutral: White
  - 3. Colors for 240-V Circuits:
    - a. Phase A: Black.
    - b. Phase B: Red.
  - 4. Colors for 480/277-V Circuits:
    - a. Phase A: Brown.
    - b. Phase B: Orange.
    - c. Phase C: Yellow.
    - d. Neutral: Gray, or White with brown tracer stripe
  - 5. Color for Equipment Grounds: Green.
  - 6. Colors for Isolated Grounds: Green with continuous yellow stripe.
  - 7. Colors for Isolated Power Circuits: Apply ½" wide purple tape at all terminations and junctions
- C. Raceways and Cables Carrying Circuits at More Than 600 V:
  - 1. Black letters on an orange field.
  - 2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."

D. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

E. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

F. Equipment Identification Labels:

1. White letters on a black field for normal power
2. White letters on a red field for emergency power
3. Provide labels for all new and modified electrical equipment, disconnect switches, motor controllers, electrical cabinets, lighting controllers, systems control panels, pushbutton stations, and similar devices.

## 2.3 LABELS

- A. Self-Adhesive Labels: thermal, transfer-printed, minimum 3-mil thick, flexible labels with acrylic pressure sensitive adhesive with clear UV, weather, and chemical resistant coating.

## 2.4 BANDS

- A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, pre-printed, solid-colored acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

## 2.5 TAPES

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

## 2.6 SIGNS AND NAMEPLATES

- A. Laminated Acrylic or Melamine Plastic Signs and Nameplates:
1. 3-ply Engraving Stock.
  2. Thickness:
    - a. Minimum 1/16-inch-thick for interior signs up to 20 sq. in.

- b. Minimum 1/8-inch-thick for interior signs larger than 20 sq. in and all damp/wet locations.
- c. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting. Exception shall be in locations where specifically approved contact type permanent adhesive may be used where screws cannot or should not penetrate substrate.

## 2.7 CABLE TIES

- A. Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon, designed for continuous exposure to exterior sunlight.
  - 1. Minimum Width: 3/16 inch.
  - 2. Tensile Strength at 73 Deg F according to ASTM D 638: 12,000 psi.
  - 3. Temperature Range: Minus 40 to plus 185 deg F.
  - 4. Color: Black, except where used for color-coding.
  - 5. UL 94 Flame Rating: 94V-0 in plenum locations.

## 2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

## **PART 3 - EXECUTION**

### 3.1 COORDINATION

- A. Coordinate with Owner for approval of all labelling codes and schemes prior to creation and installation of labeling system.
- B. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- C. The final building room numbers selected by the Owner may vary from the room numbers indicated on the drawings.
- D. Use consistent designations and color coding throughout Project. If existing labelling scheme is in place, all labelling will defer to current scheme as to stay consistent with facility.

### 3.2 PREPARATION

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

### 3.3 INSTALLATION

- A. All labels shall be mechanically produced. Write-on labels are not permitted.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Apply identification devices to surfaces that require finish after completing finish work.
- E. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- F. Labels and signs shall be installed centered, parallel to equipment lines, plumb, and neatly on front of all equipment unless noted otherwise.
- G. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- H. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- I. Identification for Electrical Equipment:
  - 1. Provide engraved laminated plastic nameplate with ½" letters for equipment/load designation and ¼" letters for supplemental system, source, and feeder information. Refer to drawings for nameplate examples.
  - 2. Apply nameplates to each piece of new or modified equipment in the following categories:
    - a. Distribution Equipment
    - b. Disconnect Switches
    - c. Motor Controllers
    - d. Electrical Cabinets and Enclosures
    - e. Lighting Controllers (Contactors, Time Clocks, Control Panels, etc.)
    - f. Auxiliary Systems Control Panels
    - g. Push-button stations
- J. Identification for Equipment circuit directories
  - 1. New and modified panelboards shall have typed directories with accurate descriptions of each branch circuit along with room numbers. In modified panelboards, the date of any changes shall be noted in the directory indicating all deletions and additions.

2. New and modified switchboards and distribution panelboards shall have each circuit breaker individually identified with load designation on engraved laminated plastic nameplate.
- K. System Identification for Raceways and Cables: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
  1. Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
  2. Secure tight to surface of conductor, cable, or raceway.
- L. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- M. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer.
- N. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
  1. "EMERGENCY POWER."
  2. "POWER."

### 3.4 IDENTIFICATION SCHEDULE

- A. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- B. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Vinyl wraparound labels.
  1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120] V to Ground: Identify with self-adhesive raceway labels.
  1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:
  1. "EMERGENCY POWER."

2. "POWER."

- E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels to identify the phase.
  - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- F. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with the conductor or cable designation, origin, and destination.
- G. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with the conductor designation.
- H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.
  - 1. Apply to exterior of door, cover, or other access.
  - 2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
    - a. Power-transfer switches.
    - b. Controls with external control power connections.
- I. Arc Flash Warning Labeling: Self-adhesive labels.
- J. Operating Instruction Signs: Self-adhesive labels.
- K. Emergency Operating Instruction Signs: Laminated acrylic or melamine plastic signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer].

**END OF SECTION**

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## **SECTION 26 05 73**

### **POWER SYSTEM STUDIES**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section includes the following computer-based studies:
  - 1. Fault-current study to determine the minimum interrupting capacity of circuit protective devices.
  - 2. Overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
  - 3. Arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

##### **1.3 DEFINITIONS**

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed and salvaged, or removed and reinstalled. Existing to remain items shall remain functional throughout the construction period.
- B. Field Adjusting Agency: An independent electrical testing agency with full-time employees and the capability to adjust devices and conduct testing indicated and that is a member company of NETA.
- C. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- D. Power System Analysis Software Developer: An entity that commercially develops, maintains, and distributes computer software used for power system studies.

- E. Power Systems Analysis Specialist: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located.
- F. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion of the circuit from the system.
- G. SCCR: Short-circuit current rating.
- H. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
- I. Single-Line Diagram: See "One-Line Diagram."

#### 1.4 REFERENCES

- A. Institute of Electrical and Electronics Engineers (IEEE)
  - 1. IEEE 141 - Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
  - 2. IEEE 242 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
  - 3. IEEE 399 - Recommended Practice for Industrial and Commercial Power System Analysis
  - 4. IEEE 241 - Recommended Practice for Electric Power Systems in Commercial Buildings
  - 5. IEEE 1015 - Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems
  - 6. IEEE 1584 - Guide for Performing Arc-Flash Hazard Calculations
- B. American National Standards Institute (ANSI)
  - 1. ANSI C57.12.00 - Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
  - 2. ANSI C37.13 - Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
  - 3. ANSI C37.010 - Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
  - 4. ANSI C 37.41 - Standard Design Tests for High Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories
- C. The National Fire Protection Association (NFPA)
  - 1. NFPA 70 - National Electrical Code
  - 2. NFPA 70E - Standard for Electrical Safety in the Workplace

## 1.5 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Preliminary Study: Submit the following prior to receiving final approval of equipment and system protective devices submittals and prior to release of equipment drawings for manufacturing. The preliminary study shall provide sufficient data to ensure that selection of equipment and devices will have adequate ratings and the protective device trip characteristics will be satisfactory.
  - 1. Study input data, including completed computer program input data sheets including assumptions on worst case project conditions.
  - 2. Study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
- C. Final Study and Report: Submit final study at the end of the construction cycle when circuits are installed and all equipment is on site and installed such that complete and accurate data can be obtained.

## 1.6 CLOSEOUT SUBMITTALS

- A. Provide five (5) bound copies of the complete final report. Additional copies shall be provided on CD or USB in PDF format.
- B. At the owner's option, provide the study project files in electronic format including all project files and libraries to allow the owner to update and print additional copies, labels, etc.

## 1.7 QUALITY ASSURANCE

- A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.
  - 1. Power System Analysis Software Qualifications: Computer program shall be designed to perform short-circuit studies or have a function, component, or add-on module designed to perform short-circuit studies.
  - 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- D. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

1. Engineer shall be a full-time employee of the electrical equipment manufacturer or a professional electrical engineering firm
  2. The engineer shall have a minimum of five (5) years' experience performing power system studies.
- E. Power System Study Certification: Report shall be signed and sealed by Power Systems Analysis Specialist.
- F. Field Adjusting Agency Qualifications:
1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
  2. A member company of NETA.

## **PART 2 - PRODUCTS:**

### **2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS**

- A. Perform studies using the latest version of Power Tools for Windows by SKM Systems Analysts.
- B. Comply with IEEE 242, IEEE 399, IEEE 551, IEEE 1584, and NFPA 70E.
- C. Analytical features of power systems analysis software program shall have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

### **2.2 POWER SYSTEM STUDY REPORT CONTENTS**

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
  1. Protective device designations and ampere ratings.
  2. Conductor types, sizes, and lengths.
  3. Transformer kilovolt ampere (kVA) and voltage ratings.
  4. Motor and generator designations and kVA ratings.
  5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
  6. Derating factors and environmental conditions.

7. Any revisions to electrical equipment required by the study.
- D. Study Input Data
1. Power sources available.
  2. Manufacturer, model, and interrupting rating of protective devices.
  3. Conductors.
  4. Transformer data.
- E. Comments and recommendations for system improvements or revisions in a written document, separate from one-line diagram.
- F. Protective Device Evaluation:
1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
  2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
  3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
  4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
  5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
- G. Short-Circuit Study Output Reports:
1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. Equivalent impedance.
  2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
    - a. Voltage.
    - b. Calculated symmetrical fault-current magnitude and angle.
    - c. Fault-point X/R ratio.
    - d. Calculated asymmetrical fault currents:
      - 1) Based on fault-point X/R ratio.
      - 2) Based on calculated symmetrical value multiplied by 1.6.
      - 3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
  - a. Voltage.
  - b. Calculated symmetrical fault-current magnitude and angle.
  - c. Fault-point X/R ratio.
  - d. No AC Decrement (NACD) ratio.
  - e. Equivalent impedance.
  - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
  - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
- H. Protective Device Coordination Study:
  1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
    - a. Phase and Ground Relays:
      - 1) Device tag.
      - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
      - 3) Recommendations on improved relaying systems, if applicable.
    - b. Circuit Breakers:
      - 1) Adjustable pickups and time delays (long time, short time, and ground).
      - 2) Adjustable time-current characteristic.
      - 3) Adjustable instantaneous pickup.
      - 4) Recommendations on improved trip systems, if applicable.
  2. Fuses: Show current rating, voltage, and class.
- I. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
  1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
  2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
  3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
  4. Plot the following listed characteristic curves, as applicable:
    - a. Power utility's overcurrent protective device.

- b. Medium-voltage equipment overcurrent relays.
  - c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
  - d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
  - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
  - f. Cables and conductors damage curves.
  - g. Ground-fault protective devices.
  - h. Motor-starting characteristics and motor damage points.
  - i. Generator short-circuit decrement curve and generator damage point.
  - j. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Maintain selectivity for tripping currents caused by overloads.
  6. Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.
  7. Provide adequate time margins between device characteristics such that selective operation is achieved.
  8. Comments and recommendations for system improvements.

J. Arc-Flash Study Output Reports:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in the report:
  - a. Voltage.
  - b. Calculated symmetrical fault-current magnitude and angle.
  - c. Fault-point X/R ratio.
  - d. No AC Decrement (NACD) ratio.
  - e. Equivalent impedance.
  - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
  - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

K. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Restricted approach boundary.
6. Limited approach boundary.
7. Working distance.
8. Incident energy.
9. Hazard risk category.
10. Recommendations for arc-flash energy reduction.

## 2.3 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch self-adhesive equipment label for each work location included in the analysis unless noted otherwise.
- B. Label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
  - 1. Location designation.
  - 2. Nominal voltage.
  - 3. Protection boundaries.
    - a. Arc-flash boundary.
    - b. Restricted approach boundary.
    - c. Limited approach boundary.
  - 4. Arc flash PPE category.
  - 5. Required minimum arc rating of PPE in Cal/cm squared.
  - 6. Available incident energy.
  - 7. Working distance.
  - 8. Engineering report number, revision number, and issue date.
- C. Labels shall be machine printed, with no field-applied markings.

## **PART 3 - EXECUTION:**

### 3.1 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the study.
  - 1. Verify completeness of data supplied on one-line diagram. Call any discrepancies to Engineer's attention.
  - 2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
  - 3. For relocated equipment and that which is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. Qualifications of technicians and engineers shall be as defined by NFPA 70E.
- B. Electrical Survey Data: Gather and tabulate the required input data to support the short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on a Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds

NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification. Data include, but are not limited to, the following:

1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus (three phase and line to ground).
5. Full-load current of all loads.
6. Voltage level at each bus.
7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
12. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
13. Motor horsepower and NEMA MG 1 code letter designation.
14. Conductor sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
15. Derating factors.
16. Data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, showing the following:
  - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
  - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
  - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
  - d. Generator thermal-damage curve.
  - e. Ratings, types, and settings of utility company's overcurrent protective devices.
  - f. Special overcurrent protective device settings or types stipulated by utility company.
  - g. Time-current-characteristic curves of devices indicated to be coordinated.
  - h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.

- i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
- j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.
- k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

### 3.2 POWER SYSTEMS STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Base study on device characteristics supplied by device manufacturer.
- C. Extent of electrical power system to be studied is indicated on Drawings including all new over-current protection devices and equipment.
- D. This contractor shall gather all necessary data from the existing facility as needed to perform the study.
- E. The Contractor shall be responsible for modifying settings on existing equipment only at the nearest existing over-current protection device which serves new equipment unless noted otherwise.
- F. Begin analysis at the service, extending down to system overcurrent protective devices as follows:
  - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
  - 2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.
- G. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- H. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.
- I. Short Circuit Study
  - 1. Calculate short-circuit currents according to IEEE 551.

2. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
  - a. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

J. Coordination Study

1. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
2. Transformer Primary Overcurrent Protective Devices:
  - a. Device shall not operate in response to the following:
    - 1) Inrush current when first energized.
    - 2) Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
    - 3) Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
  - b. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
3. Motor Protection:
  - a. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
  - b. Select protection for motors served at voltages more than 600 V according to IEEE 620.
4. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
5. Generator Protection: Select protection according to manufacturer's written instructions and to IEEE 242.

K. Arc Flash Hazard Analysis

1. Comply with NFPA 70E and its Annex D for hazard analysis study.
2. Preparatory Studies: Perform the Short-Circuit and Protective Device Coordination studies prior to starting the Arc-Flash Hazard Analysis.
3. Calculate maximum and minimum contributions of fault-current size.
  - a. Maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
  - b. Calculate arc-flash energy at 85 percent of maximum short-circuit current according to IEEE 1584 recommendations.
4. Calculate the arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.

5. Include medium- and low-voltage equipment locations, except equipment rated 240 V ac or less fed from transformers less than 125 kVA.
  6. Calculate the limited, restricted, and prohibited approach boundaries for each location.
  7. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
    - a. Fault contribution from induction motors shall not be considered beyond three to five cycles.
    - b. Fault contribution from synchronous motors and generators shall be decayed to match the actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).
  8. Arc-flash energy shall generally be reported for the maximum of line or load side of a circuit breaker. However, arc-flash computation shall be performed and reported for both line and load side of a circuit breaker as follows:
    - a. When the circuit breaker is in a separate enclosure.
    - b. When the line terminals of the circuit breaker are separate from the work location.
  9. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.
- L. Include in the report identification of any protective device applied outside its capacity.

### 3.3 ARC FLASH LABELING

- A. All labels will be based on recommended overcurrent device settings and will be provided to owner after the results of the analysis have been presented and after any system changes, upgrades, or modifications have been incorporated in the system.
- B. Apply arc-flash label on the front cover of each section of the equipment and on side or rear covers with accessible live parts and hinged doors or removable plates for each equipment included in the study. Base arc-flash label data on highest values calculated at each location.
- C. Each piece of equipment listed below shall have an arc-flash label applied to it:
  1. Motor-control center.
  2. Low-voltage switchboard.
  3. Switchgear.
  4. Medium-voltage switch.
  5. Medium voltage transformers
  6. Low voltage transformers.
  7. Panelboard and safety switch over 250 V.
  8. Applicable panelboard and safety switch under 250 V.

- 9. Control panel.
- D. Note on record Drawings the location of equipment where the personnel could be exposed to arc-flash hazard during their work.
  - 1. Indicate arc-flash energy.
  - 2. Indicate protection level required.
- E. Install arc-flash warning labels under the direct supervision and control of Power System Analysis Specialist.

### 3.4 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of equipment manufacturer under the "Startup and Acceptance Testing" contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.
- C. Notify Owner in writing of any required major modifications.
- D. Equipment shall not be energized until all breakers or protective relays are set either to the recommended values indicated by the studies or to minimum trip settings.
- E. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.

### 3.5 DEMONSTRATION

- A. Acquaint personnel in fundamentals of operating the power system in normal and emergency modes.
- B. Hand-out and explain the power system study objectives, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting time-current coordination curves.
- C. Arc Flash Training
  - 1. Train Owner's maintenance personnel in potential arc-flash hazards associated with working on energized equipment and the significance of arc-flash warning labels (minimum of 4 hours).
  - 2. The training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET) or equivalent.

3. Include in Project Close-out Documents training notes, outlines, and Power Point presentation of training session. Also include attendance record of personnel attending the training session.
4. Training session shall be videotaped. Include copy of DVD of training session in Project Close-out Documents.

**END OF SECTION**

## **SECTION 260923**

### **LIGHTING CONTROL DEVICES**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Photoelectric switches.
  - 2. Indoor occupancy and vacancy sensors.
  - 3. Switchbox-mounted occupancy sensors.
  - 4. Digital timer light switches.
  - 5. Lighting contactors.
  - 6. Emergency shunt relays.
- B. Related Requirements:
  - 1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

##### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. Show installation details for the following:
    - a. Occupancy sensors.
    - b. Vacancy sensors.
  - 2. Interconnection diagrams showing field-installed wiring.
  - 3. Include diagrams for power, signal, and control wiring.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.

#### 1.5 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.
  - 1. Failures include, but are not limited to, the following:
    - a. Faulty operation of lighting control software.
    - b. Faulty operation of lighting control devices.
  - 2. Warranty Period: Two years from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### 2.1 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Description: Solid state, with DPST dry contacts rated for 1000 W incandescent, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A, and compatible with ballasts and LED lamps.
  - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lux), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
  - 3. Time Delay: Fifteen-second minimum, to prevent false operation.
  - 4. Surge Protection: Metal-oxide varistor.
  - 5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
  - 6. Failure Mode: Luminaire stays ON.

#### 2.2 INDOOR OCCUPANCY AND VACANCY SENSORS

- A. General Requirements for Sensors:
  - 1. Wall or Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
  - 2. Dual technology.
  - 3. Separate power pack.
  - 4. Hardwired connection to switch.

5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  6. Operation:
    - a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    - b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    - c. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
  7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A.
  8. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
  9. Mounting:
    - a. Sensor: Suitable for mounting in any position on a standard outlet box.
    - b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
    - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
  10. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
  11. Bypass Switch: Override the "on" function in case of sensor failure.
  12. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.
- B. Dual-Technology Type: Wall or Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
  2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
  3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

## 2.3 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

- A. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox using hardwired connection.
  - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
  - 3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
  - 4. Switch Rating: Not less than 800-VA load at 120 V, 1200-VA LED load at 277 V, and 800-W incandescent.

## 2.4 LIGHTING CONTACTORS

- A. Description: Electrically operated and mechanically held, combination-type lighting contactors nonfused disconnect, complying with NEMA ICS 2 and UL 508.
  - 1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less THD of normal load current).
  - 2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
  - 3. Enclosure: Comply with NEMA 250.
  - 4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.
- B. Interface with DDC System for HVAC: Provide hardware interface to enable the DDC system for HVAC to monitor and control lighting contactors.
  - 1. Monitoring: On-off status.
  - 2. Control: On-off operation.

## 2.5 EMERGENCY SHUNT RELAY

- A. Description: NC, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.

## 2.6 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 SENSOR INSTALLATION**

- A. Comply with NECA 1.
- B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- C. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

#### **3.3 CONTACTOR INSTALLATION**

- A. Comply with NECA 1.
- B. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

#### **3.4 WIRING INSTALLATION**

- A. Comply with NECA 1.
- B. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch (13 mm).

- C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

### 3.5 IDENTIFICATION

- A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."
  - 1. Identify controlled circuits in lighting contactors.
  - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

### 3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
  - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Lighting control devices will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

### 3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
  - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
  - 2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
  - 3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

**END OF SECTION**

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## **SECTION 261219**

### **PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section includes pad-mounted, liquid-filled, medium-voltage distribution transformers, with primary and secondary bushings within or without air-terminal enclosures.

##### **1.3 DEFINITIONS**

- A. BIL: Basic Impulse Insulation Level.
- B. Bushing: An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.
- C. Bushing Elbow: An insulated device used to connect insulated conductors to separable insulated connectors on dead-front, pad-mounted transformers and to provide a fully insulated connection. This is also called an "elbow connector."
- D. Bushing Insert: That component of a separable insulated connector that is inserted into a bushing well to complete a dead-front, load break or nonload break, separable insulated connector (bushing).
- E. Bushing Well: A component of a separable insulated connector, either permanently welded or clamped to an enclosure wall or barrier, having a cavity that receives a replaceable component (bushing insert) to complete the separable insulated connector (bushing).
- F. Elbow Connector: See "bushing elbow" above.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For pad-mounted, liquid-filled, medium-voltage transformers.
  - 1. Include plans and elevations showing major components and features.
    - a. Include a plan view and cross section of equipment base, showing clearances, required workspace, and locations of penetrations for grounding and conduits.
  - 2. Include details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 3. Include single-line diagram.
  - 4. Include list of materials.
  - 5. Include nameplate data.
  - 6. Manufacturer's published time-current curves of the transformer high-voltage fuses, with transformer damage curve, inrush curve, and thru fault current indicated.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

### **PART 2 - PRODUCTS**

#### 2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with IEEE C2.
- C. Comply with IEEE C57.12.00.

#### 2.2 PERFORMANCE REQUIREMENTS

- A. Windings Material: Aluminum or Copper.

- B. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor (MOV) type, fully shielded, separable-elbow type, suitable for plugging into the inserts provided in the high-voltage section of the transformer. Connected in each phase of incoming circuit and ahead of any disconnecting device.
- C. Winding Connections: The connection of windings and terminal markings shall comply with IEEE C57.12.70.
- D. Efficiency: Comply with 10 CFR 431, Subpart K.
- E. Insulation: Transformer kVA rating shall be as follows: The average winding temperature rise above a 30 deg C ambient temperature shall not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested according to IEEE C57.12.90, using combination of connections and taps that give the highest average winding temperature rise.
- F. Tap Changer: Lockable, external handle, for de-energized operation.
- G. Tank: Sealed, with welded-on cover. Designed to withstand internal pressure of not less than 7 psi without permanent distortion and 15 psig without rupture. The tank shall include a 15 psig pressure relief valve with a flow rate of minimum 35 SCFM. Comply with IEEE C57.12.36. The cover shall be welded and the handhole fastenings tamper resistant. The transformer shall remain effectively sealed for a top oil temperature range of -5° C to 105° C.
- H. Enclosure Integrity: Comply with IEEE C57.12.28 for pad-mounted enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to the public.
- I. Mounting: An integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.
- J. Insulating Liquids:
  - 1. Less-Flammable Liquids:
    - a. Edible-Seed-Oil-Based Dielectric: Listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic, having passed the Organization for Economic Co-operation and Development G.L.203 with zero mortality, and shall be certified by the U.S. Environmental Protection Agency as biodegradable, meeting Environmental Technology Verification requirements. The fluid shall be Factory Mutual Approved® , UL® Classified Dielectric Medium (UL-EOUV) and UL® Classified Transformer Fluid (UL-EOVK).
- K. Sound level shall comply with NEMA TR 1 requirements.
- L. Corrosion Protection:

1. Transformer coating system shall be factory applied, complying with requirements of IEEE C57.12.28, in manufacturer's standard color green.

## 2.3 THREE-PHASE TRANSFORMERS

- A. Subject to compliance with requirements, provide product from one of the following or approved equal
  1. ABB
  2. Eaton
  3. Siemens
  4. Square D
- B. Description:
  1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  2. Comply with IEEE C57.12.26.
- C. Compartment Construction:
  1. Double-Compartment Construction: Individual compartments for high- and low-voltage sections, formed by steel isolating barriers that extend full height and depth of compartments, with hinged, lift-off doors and three-point latching, with a stop in the open position and provision for padlocking.
- D. Primary Fusing: Designed and rated to provide thermal protection of transformer by sensing overcurrent and high liquid temperature.
  1. 150-kV BIL current-limiting fuses, conforming to requirements of IEEE C37.47.
  2. Interrupting Rating: 50,000 rms A symmetrical at system voltage.
  3. Fuse Assembly: Bayonet-type, liquid-immersed, expulsion fuses in series with liquid-immersed, partial-range, current-limiting fuses. Bayonet fuse shall sense both high currents and high oil temperature to provide thermal protection to the transformer.
  4. Provide bayonet fuse assembly with an oil retention valve and an external drip shield inside the housing to eliminate or minimize oil spills. Valve shall close when fuse holder is removed and an external drip shield is installed.
  5. Provide a conspicuously displayed warning adjacent to bayonet fuse(s), cautioning against removing or inserting fuses unless transformer has been de-energized and tank pressure has been released.
- E. High-Voltage Section: Dead-front design.
  1. To connect primary cable, use separable insulated connectors; coordinated with and complying with requirements of Section 260513 "Medium-Voltage Cables." Bushings shall be one-piece units, with ampere and BIL ratings the same as connectors.

2. Bushing inserts:
  - a. Conform to the requirements of IEEE 386.
  - b. Rated at 200 A, with voltage class matching connectors. Provide a parking stand near each bushing well.
  - c. Provide insulated protective caps for insulating and sealing out moisture from unused bushing inserts.
3. Access to liquid-immersed fuses.
4. Dead-front surge arresters.
5. Tap-changer operator.
6. External Visible Load-Break Switch:
  - a. Radial-feed, liquid-immersed type with voltage class and BIL matching that of separable connectors, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12 kA rms symmetrical.
7. Ground pad.

F. Low-Voltage Section:

1. Bushings with spade terminals drilled for terminating the number of conductors indicated on the Drawings, and the lugs that comply with requirements of Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Bushing supports shall be provided for transformers requiring 10 or more connection holes. Bushing supports shall be affixed to the cabinet sidewalls; tank-mounted supports mountings are not acceptable

G. Capacities and Characteristics:

1. Power Rating (kVA): As indicated on drawings.
2. Voltage Ratings: As indicated on drawings.
3. Taps: Comply with IEEE C57.12.26 requirements.
4. Transformer BIL (kV): Comply with IEEE C57.12.26 requirements.
5. Minimum Tested Impedance (Percent at 85 deg C): 5.75 nominal.
6. Comply with FM Global Class No. 3990.
7. Comply with UL listing requirements for combination classification and listing for transformer and less-flammable insulating liquid.

H. Transformer Accessories:

1. Drain and filter connection.
2. Filling and top filter press connections.
3. Pressure-vacuum gauge.
4. Dial-type analog thermometer.
5. Magnetic liquid level.
6. Automatically resetting pressure-relief device. Device flow shall be as recommended by manufacturer.
7. Stainless-steel ground connection pads.

8. Machine-engraved nameplate, made of anodized aluminum or stainless steel.

## 2.4 SERVICE CONDITIONS

- A. Transformers shall be suitable for operation under service conditions specified as usual service conditions in IEEE C57.12.00.

## 2.5 WARNING LABELS AND SIGNS

- A. Comply with requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."
  1. High-Voltage Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s). Sign legend shall be "DANGER HIGH VOLTAGE" printed in two lines of nominal 2-inch- (50-mm)-high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.
  2. Arc Flash Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s), warning of potential electrical arc flash hazards and appropriate personal protective equipment required.

## **PART 3 - EXECUTION**

### 3.1 EXAMINATION

- A. Examine pad-mounted, liquid-filled, medium-voltage transformers upon delivery.
  1. Upon delivery of transformers and prior to unloading, inspect equipment for any damage that may have occurred during shipment or storage.
  2. Verify that tie rods and chains are undamaged and tight, and that all blocking and bracing is tight. Verify that there is no evidence of load shifting in transit, and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
  3. Verify that there is no indication of external damage and no dents or scratches in doors and sill, tank walls, radiators and fins, or termination provisions.
  4. Verify that there is no evidence of insulating-liquid leakage on transformer surfaces, at weld seams, on high- or low-voltage bushing parts, and at transformer base.
  5. Verify that there is positive pressure or vacuum on tank. Check pressure gauge; it is required to read other than zero.
  6. Compare transformers and accessories received with bill of materials to verify that shipment is complete. Verify that transformers and accessories conform with manufacturer's quotation and shop drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.
  7. Verify presence of polychlorinated biphenyl content labeling.

8. Unload transformers carefully, observing all packing label warnings and handling instructions.
9. Open termination compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:

1. Handle transformers carefully, in accordance with manufacturer recommendations, to avoid damage to enclosure, termination compartments, base, frame, tank, and internal components. Do not subject transformers to impact, jolting, jarring, or rough handling.
2. Protect transformer termination compartments against entrance of dust, rain, and snow.
3. Transport transformers upright, to avoid internal stresses on core and coil mounting assembly and to prevent trapping air in windings. Do not tilt or tip transformers.
4. Verify that transformer weights are within rated capacity of handling equipment.
5. Use only manufacturer-recommended points for lifting, jacking, and pulling. Use all lifting lugs when lifting transformers.
6. Use jacks only at corners of tank base plate.
7. Use nylon straps of same length to balance and distribute weight when handling transformers with a crane.
8. Use spreaders or a lifting beam to obtain a vertical lift and to protect transformer from straps bearing against enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
9. Exercise care not to damage tank base structure when handling transformer using skids or rollers. Use skids to distribute stresses over tank base when using rollers under large transformers.

C. Storage:

1. Store transformers in accordance with manufacturer's recommendations.
2. Transformers may be stored outdoors. If possible, store transformers at final installation locations on concrete pads. If dry concrete surfaces are unavailable, use pallets of adequate strength to protect transformers from direct contact with ground. Ensure transformer is level.
3. Ensure that transformer storage location is clean and protected from severe conditions. Protect transformers from dirt, water, contamination, and physical damage. Do not store transformers in presence of corrosive or explosive gases. Protect transformers from weather when stored for more than three months.
4. Store transformers with compartment doors closed.
5. Regularly inspect transformers while in storage and maintain documentation of storage conditions, noting any discrepancies or adverse conditions. Verify that an effective pressure seal is maintained using pressure gauges. Visually check for insulating-liquid leaks and rust spots.

- D. Examine areas and space conditions for compliance with requirements for pad-mounted, liquid-filled, medium-voltage transformers and other conditions affecting performance of the Work.
- E. Examine roughing-in of conduits and grounding systems to verify the following:
  - 1. Wiring entries comply with layout requirements.
  - 2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will cross section barriers to reach load or line lugs.
- F. Examine concrete bases for suitable conditions for transformer installation.
- G. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at transformer location.
- H. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install transformers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Division 3.
- B. Transformer shall be installed level and plumb and shall tilt less than 1.5 degrees while energized.
- C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and IEEE C2.

### 3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
  - 1. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches (765 mm) below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable, with no kinks or sharp bends.
  - 2. Make joints in grounding conductors and loops by exothermic weld or compression connector.
  - 3. Terminate all grounding and bonding conductors on a common equipment grounding terminal on transformer enclosure.
  - 4. Complete transformer tank grounding and lightning arrester connections prior to making any other electrical connections.

- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
  - 1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
  - 2. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.
- C. Terminate medium-voltage cables in incoming section of transformers according to Section 260513 "Medium-Voltage Cables."

### 3.4 SIGNS AND LABELS

- A. Comply with installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."
- B. Install warning signs as required to comply with 29 CFR 1910.269.

### 3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
  - 1. General Field-Testing Requirements:
    - a. Comply with provisions of NFPA 70B Ch. "Testing and Test Methods."
    - b. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
    - c. After installing transformer but before primary is energized, verify that grounding system at the transformer is tested at specified value or less.
    - d. After installing transformer and after electrical circuitry has been energized, test for compliance with requirements.
    - e. Visual and Mechanical Inspection:
      - 1) Verify equipment nameplate data complies with Contract Documents.
      - 2) Inspect bolted electrical connections for high resistance using one of the following two methods:
        - a) Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
        - b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's

published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.

- f. Remove and replace malfunctioning units and retest.
- g. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

2. Medium-Voltage Surge Arrester Field Tests:

a. Visual and Mechanical Inspection:

- 1) Inspect physical and mechanical condition.
- 2) Verify arresters are clean.
- 3) Verify that ground lead on each device is individually attached to a ground bus or ground electrode.

b. Electrical Test:

- 1) Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to comply with recommended minimum insulation resistance listed in that table.
- 2) Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.

3. Liquid-Filled Transformer Field Tests:

a. Visual and Mechanical Inspection:

- 1) Test dew point of tank gases if applicable.
- 2) Inspect anchorage, alignment, and grounding.
- 3) Verify bushings are clean.
- 4) Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
- 5) Verify that liquid level in tanks is within manufacturer's published tolerances.
- 6) Perform specific inspections and mechanical tests recommended by manufacturer.
- 7) Verify presence of transformer surge arresters and that their ratings are as specified.
- 8) Verify that as-left tap connections are as specified.

b. Electrical Tests:

- 1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index shall not be less than 1.0.
- 2) Perform power-factor or dissipation-factor tests on all windings according to test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.3.
- 3) Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.
- 4) Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.
- 5) Perform turns-ratio tests at tap positions. Turns-ratio test results shall not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
- 6) Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if test shows a different pattern.
- 7) Measure resistance of each winding at each tap connection, and record temperature-corrected winding-resistance values in the Operations and Maintenance Manual.
- 8) Perform an applied-voltage test on high- and low-voltage windings-to-ground. Comply with IEEE C57.12.91, Sections 10.2 and 10.9. This test is not required for single-phase transformers and for three-phase Y-Y-connected transformers.
- 9) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- 10) Remove a sample of insulating liquid according to ASTM D 923, and perform dissolved-gas analysis according to IEEE C57.104 or ASTM D 3612.

### 3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain systems.

### END OF SECTION

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## **SECTION 261329**

### **MEDIUM-VOLTAGE, PAD-MOUNTED SWITCHGEAR**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section includes pad-mounted gear consisting of a single self-supporting enclosure, containing interrupter switches and power fuses with the necessary accessory components, all completely factory-assembled and operationally checked. The interrupter switches and fuses shall be enclosed within an inner grounded steel compartment for electrical isolation and for protection from contamination. Switch terminals shall be equipped with bushings rated 600 amperes continuous, and fuse terminals and bus terminals shall be equipped with bushing wells rated 200 amperes continuous to provide for elbow connection. Bushings and bushing wells shall be mounted on the walls of the inner compartment and shall extend into termination compartments. A termination compartment shall be provided for each three-phase switch, each three-phase set of fuses, and each three-phase set of bus terminals.

##### **1.3 DEFINITIONS**

- A. BIL: Basic Impulse Insulation Level.
- B. Bushing: An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier, conducting or otherwise, for insulating the conductor from the barrier and conducting current from one side of the barrier to the other.
- C. Bushing Elbow: An insulated device used to connect insulated conductors to separable insulated connectors on dead-front, pad-mounted switchgear and to provide a fully insulated connection. Also called an "elbow connector."
- D. Bushing Insert: That component of a separable insulated connector that is inserted into a bushing well to complete a dead-front, load break or non-load break, separable insulated connector (bushing).
- E. Bushing Well: A component of a separable insulated connector, either permanently welded or clamped to an enclosure wall or barrier, having a cavity that receives a

replaceable component (bushing insert) to complete the separable insulated connector (bushing).

- F. Fault Interrupter: A self-controlled mechanical switching device capable of making, carrying, and automatically interrupting an alternating current. It includes an assembly of control elements to detect overcurrents and control the fault interrupter. A fault interrupter always consists of a switching device, a control unit, and sensors for current and/or voltage sensing.
- G. Hotstick: An insulated stick, usually made of fiberglass, that is used to work energized overhead conductors and operate electrical equipment that is overhead, underground, and compartmentalized.
- H. NETA ATS: InterNational Electrical Testing Association, Acceptance Testing Specification.
- I. SCADA: Supervisory control and data acquisition.
- J. Way: A three-phase or single-phase circuit connection to the bus that may contain combinations of switches and protective devices or may be a solid bus.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
  - 2. Time-current characteristic curves for overcurrent protective devices.
- B. Shop Drawings: For pad-mounted switchgear.
  - 1. Include a tabulation of installed devices with features and ratings.
  - 2. Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations shall show major components and features, and they will mimic bus diagram.
  - 3. Include a plan view and cross section of equipment base showing clearances, manufacturer's recommended work space, and locations of penetrations for grounding and conduits. Show location of anchor bolts and leveling channels.
  - 4. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, and location and size of each field connection.
  - 5. Include list of materials.
  - 6. Locate accessory and spare equipment storage.
  - 7. Include single-line diagram.
  - 8. Include control power wiring diagrams.
  - 9. Include copy of nameplate.
  - 10. Switchgear Ratings:
    - a. Voltage.

- b. Continuous current.
  - c. Short-circuit rating.
  - d. BIL.
11. Wiring Diagrams: For each switchgear assembly, include the following:
- a. Power, signal, and control wiring.
  - b. Three-line diagrams of current and future secondary circuits, showing device terminal numbers and internal diagrams.
  - c. Schematic control diagrams.
  - d. Diagrams showing connections of component devices and equipment.

## 1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings:
- 1. Dimensioned concrete base, outline of switchgear, conduit entries, and grounding equipment locations.

## 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For switchgear and switchgear components to include in emergency, operation, and maintenance manuals.
- 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
    - a. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
    - b. Time-current curves, including selectable ranges for each type of overcurrent protective device.
    - c. Record as-left set points of adjustable devices.

## **PART 2 - PRODUCTS**

### 2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide product indicated on the drawings.

### 2.2 SYSTEM DESCRIPTION

- A. Manufactured Unit: Pad-mounted switchgear, designed for application in underground distribution systems.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- C. Comply with IEEE C2.
- D. Comply with IEEE C37.74.

## 2.3 PERFORMANCE REQUIREMENTS

- A. Service Conditions:
  - 1. Switchgear shall be suitable for operation under service conditions specified as usual service conditions in IEEE C37.20.3.

## 2.4 RATINGS

- A. Switchgear is applied to a nominal 12.47 kV (L-L) medium-voltage electrical power system. Minimum ratings of the switchgear shall be as follows:
  - 1. Rated Maximum Voltage and Rated BIL: 15.5 kV and 95 kV BIL.
  - 2. Continuous and Load Interrupting Current: 600 A.

## 2.5 SWITCHGEAR ENCLOSURE

- A. Weatherproof enclosure with an integral skid mounting frame, designed for mounting on a concrete pad, suitable to allow skidding or rolling of the switchgear in any direction, and with provision for anchoring the frame to the pad.
- B. Enclosure Integrity: Comply with IEEE C57.12.28 for compartmentalized enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to the public.
  - 1. Each section shall have the following features:
    - a. Structural design and anchorage adequate to resist loads imposed by 125-mph wind.
- C. Corrosion Protection: Enclosure coating system shall be factory applied, meeting the requirements of IEEE C57.12.28, in manufacturer's standard color green.

## 2.6 SWITCHGEAR CONSTRUCTION

- A. Dead-front switchgear.
- B. High Voltage Bus
  - 1. Bus and interconnections shall consist of aluminum bar of 56% IACS conductivity.
  - 2. (b) Bus and interconnections shall withstand the stresses associated with short-circuit currents up through the maximum rating of the pad-mounted gear.

C. Termination Compartments.

1. Termination compartments for switches shall have bushings, and termination compartments for fuses shall have bushing wells to permit connection of elbows. The bushings and bushing wells shall be mounted on the interior walls at a minimum height of 33 inches above the enclosure base.
2. Termination compartments for bus shall have bushing wells to permit connection of elbows. The bushing wells shall be mounted on the interior walls at a minimum height of 25 inches above the enclosure base.
3. Termination compartments for bushings rated 600 amperes continuous shall be of an adequate depth to accommodate two 600-ampere elbows mounted piggyback, encapsulated surge arresters or grounding elbows mounted on 600-ampere elbows having 200-ampere interfaces, or other similar accessory combinations without the need for an enclosure extension.
4. Termination compartments for bushing wells rated 200 amperes continuous shall be of an adequate depth to accommodate 200-ampere elbows mounted on portable feedthrus or standoff insulators, or other similar accessory combinations without the need for an enclosure extension.
5. Termination compartments shall be provided with one parking stand for each bushing or bushing well. The parking stand shall be located immediately adjacent to the associated bushing or bushing well and shall accommodate standard feedthrus and standoff insulators, and other similar accessories.
6. Each termination compartment for a switch shall be equipped with a viewing window to allow visual inspection of interrupter switch blades to allow positive verification of switch position.
7. Each termination compartment for a set of fuses shall be equipped with a set of viewing windows to allow visual inspection of blown-fuse indicators.

D. Grounding: Provision to make grounding cable and wire connections at each way.

2.7 INTERRUPTER SWITCHES

- A. Interrupter switches shall be enclosed in an inner steel compartment and shall be provided with bushings rated 600 amperes continuous to permit connection of elbows external to the switch compartment.
- B. Interrupter switches shall have a three-time duty-cycle fault-closing rating equal to or exceeding the short-circuit rating of the pad-mounted gear. These ratings define the ability to close the interrupter switch three times against a three-phase fault with asymmetrical current in at least one phase equal to the rated value, with the switch remaining operable and able to carry and interrupt rated current. Tests substantiating these ratings shall be performed at maximum voltage with current applied for at least 10 cycles. Certified test abstracts establishing such ratings shall be furnished upon request.
- C. Interrupter switches shall be operated by means of an externally accessible 3/4-in. hex switch-operating hub. The switch-operating hub shall be located within a recessed stainless-steel pocket mounted on the side of the pad-mounted gear enclosure and shall accommodate a 3/4-in. deep-socket wrench or a 3/4-in. shallow-socket wrench with extension. The switch-operating-hub pocket shall include a padlockable stainless-

steel access cover that shall incorporate a hood to protect the padlock shackle from tampering. Stops shall be provided on the switch-operating hub to prevent overtravel and thereby guard against damage to the interrupter switch quick-make quick-break mechanism. Labels to indicate switch position shall be provided in the switch-operating-hub pocket.

- D. Each interrupter switch shall be provided with a folding switch-operating handle. The switch-operating handle shall be secured to the inside of the switch-operating-hub pocket by a brass chain. The folded handle shall be stored behind the closed switch-operating-hub access cover.
- E. Interrupter switches shall utilize a quick-make quick-break mechanism installed by the switch manufacturer. The quick-make quick-break mechanism shall be integrally mounted on the switch frame, and shall swiftly and positively open and close the interrupter switch independent of the switch-operating-hub speed.
- F. Each interrupter switch shall be completely assembled and adjusted by the switch manufacturer on a single rigid mounting frame. The frame shall be of welded steel construction such that the frame intercepts the leakage path which parallels the open gap of the interrupter switch to positively isolate the load circuit when the interrupter switch is in the open position.
- G. Interrupter switch contacts shall be backed up by stainless-steel springs to provide constant high contact pressure.
- H. Interrupter switches shall be provided with a single blade per phase for circuit closing, including fault closing, continuous current carrying, and circuit interrupting. Spring-loaded auxiliary blades shall not be permitted. Interrupter switch blade supports shall be permanently molded in place in a unified insulated shaft constructed of the same cycloaliphatic epoxy resin as the insulators.
- I. Circuit interruption shall be accomplished by use of an interrupter which is positively and inherently sequenced with the blade position. It shall not be possible for the blade and interrupter to get out of sequence. Circuit interruption shall take place completely within the interrupter, with no external arc or flame. Any exhaust shall be vented in a controlled manner through a deionizing vent.

## 2.8 FUSES

- A. Solid-Material Power Fuses
  - 1. Solid-material power fuses shall utilize refill-unit-and-holder or fuse-unit-and-end-fitting construction. The refill unit or fuse unit shall be readily replaceable and low in cost.
  - 2. Fusible elements shall be nonaging and non-damageable so it is unnecessary to replace unblown companion fuses following a fuse operation.
  - 3. Fusible elements for refill units or fuse units, rated 10 amperes or larger, shall be helically coiled to avoid mechanical damage due to stresses from current surges.
  - 4. Fusible elements that carry continuous current shall be supported in air to help prevent damage from current surges.

5. Refill units and fuse units shall have a single fusible element to eliminate the possibility of unequal current sharing in parallel current paths
  6. Solid-material power fuses shall have melting time-current characteristics that are permanently accurate to within a maximum total tolerance of 10% in terms of current. Time-current characteristics shall be available which permit coordination with source-side and load-side protective relays, automatic circuit reclosers, and other fuses.
  7. Solid-material power fuses shall be capable of detecting and interrupting all faults, whether large, medium, or small (down to minimum melting current); under all realistic conditions of circuitry; and with line-to-line or line-to-ground voltage across the fuse. They shall be capable of handling the full range of transient recovery voltage severity associated with these faults.
  8. All arcing accompanying solid-material power fuse operation shall be contained within the fuse, and all arc products and gases evolved shall be effectively contained within the exhaust control device during fuse operation.
  9. Solid-material power fuses shall be equipped with a blown-fuse indicator that shall provide visible evidence of fuse operation while installed in the fuse mounting.
- B. Fuse mountings shall be enclosed in an inner steel compartment and shall be provided with bushing wells rated 200 amperes continuous for elbow connection.
- C. A fuse-storage feature shall be provided in source interrupter-switch compartment(s). Each fuse-storage feature shall provide space for storing three spare fuse holders or fuse units with end fittings for solid-material power fuses, or two spare electronic power fuse holders.

## 2.9 BUSHINGS

- A. Separable insulated connectors shall be used to connect primary cable. Comply with requirements in Section 260513 "Medium-Voltage Cables."
1. Bushings: One-piece, 600 A, BIL ratings the same as the connectors. Comply with IEEE 386.
    - a. Bushings and bushing wells shall be of a cycloaliphatic epoxy resin system
    - b. Bushings and bushing wells shall be mounted in such a way that the semiconductive coating is solidly grounded to the enclosure.
    - c. Bushings rated 600 amperes continuous shall have a removable threaded stud so that the bushings are compatible with all 600-ampere elbow systems—those requiring a threaded stud as well as those that do not.
  2. Supply a standoff bracket or parking stand for each bushing, mounted horizontally adjacent to each bushing.

## 2.10 SURGE ARRESTERS

- A. Distribution class; metal-oxide-varistor type, fully shielded, separable elbow type, suitable for plugging into the inserts. Comply with IEEE C62.11 and IEEE 386.

## 2.11 WARNING LABELS AND SIGNS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for labels and signs.
  - 1. High-Voltage Warning Label: Self-adhesive labels on the outside of the high-voltage compartment door(s). Legend shall be "DANGER HIGH VOLTAGE" printed in two lines of minimum 2-inch (50 mm) high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.
  - 2. Arc-Flash Warning Label: Self-adhesive labels on the outside of the high-voltage compartment door(s), warning of potential electrical arc-flash hazards and appropriate personal protective equipment required.

## **PART 3 - EXECUTION**

### 3.1 EXAMINATION

- A. Upon delivery of switchgear and prior to unloading, inspect equipment for damage.
  - 1. Examine tie rods and chains to verify they are undamaged and tight and that blocking and bracing are tight.
  - 2. Verify that there is no evidence of load shifting in transit and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
  - 3. Examine switchgear for external damage, including dents or scratches in doors and sill, and termination provisions.
  - 4. Compare switchgear and accessories received with the bill of materials to verify that the shipment is complete. Verify that switchgear and accessories conform to the manufacturer's quotation and Shop Drawings. If the shipment is not complete or does not comply with project requirements, notify the manufacturer in writing immediately.
  - 5. Unload switchgear, observing packing label warnings and handling instructions.
  - 6. Open compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.
- B. Handling:
  - 1. Handle switchgear, according to manufacturer's recommendations; avoid damage to the enclosure, termination compartments, base, frame, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.
  - 2. Transport switchgear upright to avoid internal stresses on equipment mounting assemblies. Do not tilt or tip switchgear.
  - 3. Use spreaders or a lifting beam to obtain a vertical lift and to protect switchgear from straps bearing against the enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.

4. Do not damage structure when handling switchgear.

C. Storage:

1. Switchgear may be stored outdoors. If possible, store switchgear at final installation locations on concrete pads. If dry concrete surfaces are not available, use pallets of adequate strength to protect switchgear from direct contact with the ground. Ensure switchgear is level.
2. Protect switchgear from physical damage. Do not store switchgear in the presence of corrosive or explosive gases.
3. Store switchgear with compartment doors closed.

D. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders have to cross section barriers to reach load or line lugs.

E. Pre-Installation Checks:

1. Verify removal of any shipping bracing after placement.

F. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at switchgear location.

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

### 3.2 SWITCHGEAR INSTALLATION

A. Comply with NECA 1.

B. Equipment Mounting:

1. Install switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Division 03.

C. Install level and plumb, tilting less than 1.5 degrees when energized.

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

E. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and IEEE C2.

### 3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable with no kinks or sharp bends.
  2. Make joints in grounding conductors and loops by exothermic weld or compression connector.
  3. Terminate all grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure.
  4. Complete the switchgear grounding and surge protector connections prior to making any other electrical connections.
- B. Terminate medium-voltage cables in incoming section of switchgear according to Section 260513 "Medium-Voltage Cables."

### 3.4 SIGNS AND LABELS

- A. Comply with the installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."
- B. Install warning signs as required to comply with OSHA 29 CFR 1910.269.

### 3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. General Field-Testing Requirements:
1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" chapter.
  2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
  3. After installing switchgear but before primary is energized, verify that grounding system at the switchgear is tested at the specified value or less.
  4. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.
- C. Medium-Voltage Switchgear Field Tests:
1. Visual and Mechanical Inspection:
    - a. Inspect bolted electrical connections using calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

- b. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
  - 1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
  - 2) Make key exchange with devices operated in off-normal positions.
- 2. Electrical Tests:
  - a. Inspect bolted electrical connections using a low-resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
  - b. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.
    - 1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
    - 2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.
  - c. Perform current-injection tests on the entire current circuit in each section of switchgear.
    - 1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
    - 2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
  - d. Perform system function tests according to "System Function Tests" Article.
  - e. Verify operation of space heaters.
  - f. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.
- D. Switchgear will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

**3.6 SYSTEM FUNCTION TESTS**

- A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after "Field Quality Control" tests have been completed and all components have passed specified tests.
  - 1. Develop test parameters and perform tests for evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
  - 2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.

**3.7 DEMONSTRATION**

- A. Train Owner's maintenance personnel to adjust, operate, and maintain systems.

**END OF SECTION**

## **SECTION 26 24 13**

### **SWITCHBOARDS**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Applicable general requirements for electrical Work specified within Division 26 Specification Sections apply to this Section.

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Service and distribution switchboards rated 600 V and less.
  - 2. Surge protection devices.
  - 3. Disconnecting and overcurrent protective devices.
  - 4. Instrumentation.
  - 5. Control power.
  - 6. Accessory components and features.
  - 7. Identification.

##### **1.3 REFERENCES**

- A. The following publications are referred to in the text by the basic designation only. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
- B. National Electrical Contractors Association (NECA):
  - 1. NECA 400, "Standard for Installing and Maintaining Switchboards"
- C. National Electrical Manufacturers Association (NEMA):
  - 1. NEMA AB 1, "Molded Case Circuit Breakers and Molded Case Switches."
  - 2. NEMA PB 2, "Deadfront Distribution Switchboards."
  - 3. NEMA PB 2.1, "General Instructions for Proper Handling, Installation, Operation and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less."
- D. Underwriter Laboratories (UL):

1. UL 50, "Enclosures for Electrical Equipment, Non-Environmental Considerations."
2. UL 489, "Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures."
3. UL 891, "Standard for Dead-Front Switchboards"

#### 1.4 ACTION SUBMITTALS

A. Product Data: For each switchboard.

1. Include materials, switching and overcurrent protective device, surge protection device, ground-fault protector, accessory, and components indicated.
2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include schematic and wiring diagrams for power, signal, and control wiring.

#### 1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for switchboards and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.

#### 1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

#### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path. Remove and replace access fencing, doors, lift-out panels, and structures as required to provide pathway for moving switchboards into place.
- B. Handle and prepare switchboards for installation according to NECA 400 and NEMA PB 2.1.

#### 1.8 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

#### 1.9 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within Three years from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### 2.1 SWITCHBOARDS

- A. Subject to compliance with requirements, provide product from one of the following:
  1. Eaton
  2. Siemens
  3. Square D

- B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Distribution equipment sizes and equipment layouts shall be considered basis of design. Equipment sizes vary by manufacturer. If proposed equipment is larger than the sizes illustrated, the burden shall be on the Contractor to provide equipment which fits in the space allotted while maintaining all code-required and manufacturer-recommended clearances.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NEMA PB 2, NFPA 70, and UL 891.
- F. Front-Connected, Front-Accessible Switchboards unless noted otherwise:
  - 1. Main Devices: Fixed, individually mounted unless noted otherwise.
  - 2. Branch Devices: Panel mounted.
  - 3. Sections front and rear aligned.
- G. Nominal System Voltage and Main Bus Ratings as indicated on drawings.
- H. Indoor Enclosures: Steel, NEMA 250, Type 1. with factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- I. Barriers: Between adjacent switchboard sections.
- J. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.
- K. Customer Metering Compartment: Where indicated, provide a separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.
- L. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- M. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- N. Provide Pull Box on Top of Switchboard when required by quantities and sizes of feeders:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Set back from front to clear any circuit-breaker removal mechanisms.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

O. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity.
3. Copper feeder circuit-breaker line connections. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
5. Ground Bus: Sized per NEC and UL 891 Tables, hard-drawn copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors.
6. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
7. Disconnect Links:
  - a. Isolate neutral bus from incoming neutral conductors.
  - b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
8. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
9. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

P. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

## 2.2 SURGE PROTECTION DEVICES

- A. Comply with section 264313 - Surge Protection for Low-Voltage Electrical Power Circuits

## 2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, 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 circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings where indicated:
    - a. Instantaneous trip.
    - b. Long- and short-time pickup levels.
    - c. Long and short time adjustments.
    - d. Ground-fault pickup level, time delay, and  $I^2t$  response.
  4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
  5. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
  6. MCCB Features and Accessories:
    - a. Standard frame sizes, trip ratings, and number of poles.
    - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
    - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    - d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    - e. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at **55** percent of rated voltage.
    - f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
- B. Insulated-Case Circuit Breaker (ICCB): Fully rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
1. Fixed circuit-breaker mounting unless otherwise indicated.
  2. Two-step, stored-energy closing.
  3. Trip Units: Microprocessor-based trip units with interchangeable rating plug, LED trip indicators, and the following field-adjustable settings where indicated:
    - a. Instantaneous trip.
    - b. Long- and short-time pickup levels.
    - c. Long-time and short-time time adjustments with  $I^2t$  response.
    - d. Ground-fault pickup level, time delay, and  $I^2t$  response.
  4. Control Voltage: Match control power supply.

## 2.4 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, and the following:

1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
  - a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
  - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
  - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
  - d. Megawatts: Plus or minus 1 percent.
  - e. Megavars: Plus or minus 1 percent.
  - f. Power Factor: Plus or minus 1 percent.
  - g. Frequency: Plus or minus 0.1 percent.
  - h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
  - i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
  - j. Contact devices to operate remote impulse-totalizing demand meter.
2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

## 2.5 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.
- B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

## 2.6 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

## 2.7 IDENTIFICATION

- A. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
- B. Warning labels and nameplates shall be present at access locations to advise personnel of possible hazards. The switchboard shall be marked in accordance with UL, NFPA 70 NEC, NFPA 70E, and other applicable standards.
- C. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.
- D. All identification and warning labels and nameplates exterior to the SWBD shall be resistant to their intended installation environment.

## **PART 3 - EXECUTION**

### 3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NECA 400 and NEMA PB 2.1.
  - 1. Lift or move switchboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
  - 2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
  - 3. Protect from moisture, dust, dirt, and debris during storage and installation.
  - 4. Install temporary heating during storage as required by manufacturer's instructions.
- B. Examine switchboard interior and exterior before installation. Reject switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.
  - 1. Check that concrete pads are level and free of irregularities.
  - 2. Installation space is enclosed and weatherproof.
  - 3. Any wet-work located in or in close proximity to switchboard installation location is completed and nominally dry.
  - 4. Work above ceilings is complete

- D. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Install switchboards and accessories according to NECA 400 and NEMA PB 2.1.
- B. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness. Comply with Division 03 requirements and American Concrete Institute standards for concrete bases.
  - 1. Concrete base shall be reinforced with #4 rebar on 6-inch by 6-inch centers unless noted otherwise.
  - 2. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
  - 3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
  - 4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - 5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - 6. Install anchor bolts to elevations required for proper attachment to switchboards.
  - 7. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.
- C. Temporary Lifting Provisions: Remove any temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
- D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including any control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- E. Install filler plates in unused spaces of panel-mounted sections.
- F. Install overcurrent protective devices, surge protection devices, and instrumentation.
  - 1. Set field-adjustable switches and circuit-breaker trip ranges in accordance with final approved power systems study recommendations.
- G. Comply with NECA 1.

### 3.3 CONNECTIONS

- A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.
- B. Support and secure conductors within the switchboard according to NFPA 70.

### 3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

### 3.5 FIELD QUALITY CONTROL

- A. Functional testing, commissioning, and first parameter adjusting shall be carried out by a factory trained manufacturer's representative field service engineer.
  - 1. Acceptance Testing:
    - a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
    - b. The insulation resistance of each bus structure phase-to-phase and phase-to-ground for one minute each, at minimum test voltage of 1000 Vdc; minimum acceptable value for insulation resistance is 1 megohms. Refer to manufacturer's literature for specific testing procedures.
    - c. Test continuity of each circuit.
    - d. Physically test key interlock systems to check for proper functionality prior to energizing.
  - 2. Test any ground-fault protection of equipment for service equipment per NFPA 70.
  - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification (ATS). Certify compliance with test parameters.

4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

B. Switchboard will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

### 3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges in accordance with recommendations in final approved power systems study.

### 3.7 DEMONSTRATION AND TRAINING

A. Engage a factory-trained instructor to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

B. Training shall consist of not less than one session with four hours of onsite classroom and hands-on instruction for a minimum of four attendees. Training shall cover the following topics at a minimum:

1. Theory of operation
2. Operation of Switchboard and components
3. Maintenance and configuration
4. Troubleshooting and Repair
5. Replacement of components

### END OF SECTION

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## **SECTION 26 24 16**

### **PANELBOARDS**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Lighting and appliance branch-circuit panelboards.
  - 2. Load centers.

##### **1.3 DEFINITIONS**

- A. ATS: Acceptance testing specification.
- B. GFCI: Ground-fault circuit interrupter.
- C. GFEP: Ground-fault equipment protection.
- D. HID: High-intensity discharge.
- E. MCCB: Molded-case circuit breaker.
- F. SPD: Surge protective device.
- G. VPR: Voltage protection rating.

##### **1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of panelboard.
  - 1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
  - 2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of NRTL listing for SPD as installed in panelboard.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
  1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

#### 1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. Keys: Two spares for each type of panelboard cabinet lock.

#### 1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

#### 1.8 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NECA 407 and NEMA PB 1.

1.9 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 8 months from date of Substantial Completion.

**PART 2 - PRODUCTS**

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

- A. Subject to compliance with requirements, provide product from one of the following:
1. Eaton
  2. Siemens
  3. Square D
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.
- F. Enclosures: Flush or Surface-mounted, as indicated on Drawings, dead-front cabinets.
1. Rated for environmental conditions at installed location.
    - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
    - b. Outdoor Locations: NEMA 250, Type 3R.
  2. Height: 84 inches maximum.
  3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
  4. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
  5. Finishes:
    - a. Panels and Trim: galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    - b. Back Boxes: Galvanized steel with same finish as panels and trim.

G. Incoming Mains:

1. Location: Field Convertible between top and bottom.
2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.

H. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.
  - a. Plating shall run entire length of bus.
  - b. Bus shall be fully rated the entire length with one continuous bus bar per phases.
2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
6. Extra-Capacity Neutral Bus: Where indicated provide, neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.

I. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations shall allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

J. NRTL Label: Panelboards or load centers shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Coordinate with utility company for exact requirements.

- K. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
  - 1. Percentage of Future Space Capacity: Ten percent.
- L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
  - 1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
  - 2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.
  - 3. Panelboard and over current protective device short circuit ratings shall be at least 110% of the actual available fault current.

## 2.2 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- B. Mains: Circuit breaker or lugs only, as indicated on Drawings.
- C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- D. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

## 2.3 LOAD CENTERS

- A. Load Centers: Comply with UL 67.
- B. Mains: Circuit breaker or lugs only, as indicated on Drawings.
- C. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
- D. Doors: Concealed hinges secured with flush latch with tumbler lock; keyed alike.
- E. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

## 2.4 OVERCURRENT PROTECTIVE DEVICES

- A. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.
  - 1. Thermal-Magnetic Circuit Breakers:
    - a. Inverse time-current element for low-level overloads.
    - b. Instantaneous magnetic trip element for short circuits.
    - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  - 2. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
  - 3. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
  - 4. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
  - 5. Subfeed Circuit Breakers: Vertically mounted.
  - 6. Provide the following MCCB Features and Accessories, where indicated:
    - a. Standard frame sizes, trip ratings, and number of poles.
    - b. Breaker handle indicates tripped status.
    - c. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
    - d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    - e. Shunt Trip: trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
    - f. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
    - g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
    - h. Multipole units enclosed in a single housing with a single handle.
    - i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
    - j. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

## 2.5 IDENTIFICATION

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.

1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.
2. Room numbers shall be coordinated with final room numbers as selected by Owner, not numbers on Contract Documents.

## 2.6 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

## **PART 3 - EXECUTION**

### 3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NECA 407 and NEMA PB 1.1.
- C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Comply with NECA 1.
- C. Install panelboards and accessories according to NECA 407 and NEMA PB 1.1.
- D. Equipment Mounting:
  1. Attach panelboard to the vertical finished or structural surface behind the panelboard.

- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- F. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- G. Mount panelboard cabinet plumb and rigid without distortion of box.
- H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- I. Where building surface is unsuitable, provide steel slotted supports 5/8 inch in depth. Orient steel slotted supports vertically.
- J. Install overcurrent protective devices and controllers not already factory installed.
  - 1. Set field-adjustable, circuit-breaker trip ranges.
  - 2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.
- K. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
- L. Install filler plates in unused spaces.
- M. Stub four 1-inch (25 mm) empty conduits from flush mount panelboards into accessible ceiling space or space designated to be ceiling space in the future.

### 3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

### 3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
  - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
  - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers.
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Panelboards will be considered defective if they do not pass tests and inspections.

### 3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in the Coordination Study.

### 3.6 PROTECTION

- A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

**END OF SECTION**

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## **SECTION 26 27 26**

### **WIRING DEVICES**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Standard-grade receptacles.
  - 2. USB receptacles.
  - 3. GFCI receptacles.
  - 4. SPD receptacles.
  - 5. Twist-locking receptacles.
  - 6. Pendant cord-connector devices.
  - 7. Cord and plug sets.
  - 8. Toggle switches.
  - 9. Wall plates.
  - 10. Floor service fittings.
  - 11. Poke-through assemblies.

##### **1.3 DEFINITIONS**

- A. AFCI: Arc-fault circuit interrupter.
- B. BAS: Building automation system.
- C. EMI: Electromagnetic interference.
- D. GFCI: Ground-fault circuit interrupter.
- E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- F. RFI: Radio-frequency interference.
- G. SPD: Surge protective device.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

### **PART 2 - PRODUCTS:**

#### 2.1 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Comply with NFPA 70.
- C. RoHS compliant.
- D. Comply with NEMA WD 1.
- E. Devices for Owner-Furnished Equipment:
  - 1. Receptacles: Match plug configurations.
  - 2. Cord and Plug Sets: Match equipment requirements.
- F. Device Color:
  - 1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
  - 2. Wiring Devices Connected to Essential Electrical System: Red.
  - 3. SPD Devices: Blue.
  - 4. Isolated-Ground Receptacles: Orange or as specified above with orange triangle on face.
- G. Wall Plate Color: For plastic covers, match device color unless noted otherwise.
- H. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.
- I. Manufacturers: Subject to compliance with requirements, provide product indicated or equal from one of the following:
  - 1. Eaton/Arrow Hart
  - 2. Hubbell
  - 3. Leviton
  - 4. Pass & Seymour/Legrand

## 2.2 STRAIGHT-BLADE RECEPTACLES

- A. Heavy Duty, Specification Grade Receptacle, Comply with NEMA WD 6, UL 498, FS W-C-596.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Duplex	20A, 125V	NEMA 5-20R	Hubbell 5362
Single	20A, 125V	NEMA 5-20R	Hubbell 5361
Duplex Tamper Resistant	20A, 125V	NEMA 5-20R	Hubbell 5362TR
Duplex Isolated Ground	20A, 125V	NEMA 5-20R	Hubbell IG5362
Duplex Weather Resistant	20A, 125V	NEMA 5-20R	Hubbell 5362WR
Duplex Corrosion Resistant	20A, 125V	NEMA 5-20R	Hubbell 53CM62
Single	30A, 250V	NEMA 6-30R	Hubbell 9330
Single	50A, 250V	NEMA 6-50R	Hubbell 9367

## 2.3 USB RECEPTACLES

- A. USB Charging Receptacle and Outlet, Comply with UL 1310 and USB 3.0 devices :
- B. Dual port, combination USB Type A and C, 5 V dc, and 5 A per receptacle (minimum).

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Duplex USB	20A, 125V	NEMA 5-20R	Hubbell USB20AC5
Duplex USB Weather Resistant	20A, 125V	NEMA 5-20R	Hubbell USB20AC5WR

## 2.4 GFCI RECEPTACLES

- A. Heavy Duty Specification Grade GFCI Receptacles, Comply with UL 498, FS W-C-596, and UL 943 Class A:
- B. Non-feed through type, Integral self-testing GFCI with "Test" and "Reset" buttons and LED indicator light that is lighted when the unit is tripped. If critical components are damaged and ground fault protection is lost, power to receptacle shall be discontinued.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Duplex GFCI	20A, 125V	NEMA 5-20R	Hubbell GF5362
GFCI Blank Face	20A, 125V		Hubbell GFBFHP20

## 2.5 SPD RECEPTACLES

- A. Heavy Duty Specification Grade SPD Receptacles, Comply with UL 498, FS W-C-596, and UL 1449:
- B. Self-grounding. Integral SPD in line to ground, line to neutral, and neutral to ground. Visual and audible SPD indication, with LED indicator light visible in face of device to indicate device is "active" or "no longer in service."
- C. SPD Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 500 V and minimum single transient pulse energy dissipation of 340 J in each mode, according to IEEE C62.41.2 and IEEE C62.45.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Duplex SPD	20A, 125V	NEMA 5-20R	Hubbell 5362SA

## 2.6 TWIST-LOCKING RECEPTACLES

- A. Twist-Lock, Single Receptacles, with matching plug as required by equipment. Comply with NEMA WD 6, UL 498, FS W-C-596.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Single	20A, 125V	NEMA L5-20R	Hubbell 2310
Single	20A, 250V	NEMA L6-20R	Hubbell 2320
Single	20A, 277V	NEMA L7-20R	Hubbell 2330

## 2.7 PENDANT CORD-CONNECTOR DEVICES

- A. Description: Matching, locking-type plug and receptacle body connector, heavy-duty grade.

- B. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
- C. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

## 2.8 CORD AND PLUG SETS

- A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
- B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
- C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

## 2.9 TOGGLE SWITCHES

- A. Switches, 120/277 V, Comply with UL 20 and FS W-S-896.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Single Pole	20A, 120/277V		Hubbell 1221
Double Pole	20A, 120/277V		Hubbell 1222
Three Way	20A, 120/277V		Hubbell 1223
Four Way	20A, 120/277V		Hubbell 1224

- B. Pilot-Light Switches, illuminated when switch is ON:

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Single Pole	20A, 120/277V		Hubbell 1221PL

- C. Illuminated Switches, illuminated when switch is OFF:

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Single Pole	20A, 120/277V		Hubbell 1221IL

D. Key-Operated Switches, Factory-supplied key in lieu of switch handle:

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Single Pole	20A, 120/277V		Hubbell 1221L
Three Way	20A, 120/277V		Hubbell 1223L
Four Way	20A, 120/277V		Hubbell 1224L

E. Double-Throw, Momentary-Contact, Center-off Switches, for use with mechanically held lighting contactors.

TYPE	RATING	CONFIGURATION	BASIS OF DESIGN
Single Pole	20A, 120/277V		Hubbell 1557
Low Voltage	5A, 24VDC		Hubbell 1557LV

## 2.10 WALL PLATES

- A. Single Source: Obtain wall plates from same manufacturer of wiring devices.
- B. Single and combination types shall match corresponding wiring devices.
  - 1. Plate-Securing Screws: Metal with head color to match plate finish.
  - 2. Material for Finished Spaces: 0.035-inch-thick, satin-finished, Type 302 stainless steel.
  - 3. Material for Unfinished Spaces: **Galvanized steel.**
  - 4. Material for Rough Service Locations including gymnasiums, kitchens, mechanical rooms, material management, and food service areas: **0.035-inch-thick, satin-finished, Type 302 stainless steel**
  - 5. Material for Interior Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- C. Exterior Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, gasketed, die-cast aluminum with lockable in-use cover.

## PART 3 - EXECUTION

### 3.1 PROTECTION

- A. Protect installed products until completion of project.

- B. Devices that have been installed before painting shall be masked. No plates or covers shall be installed until all finishing and cleaning has been completed.
- C. Touch-up, repair or replace damaged products before Substantial Completion.

### 3.2 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Receptacles and cover plates shall be listed for installed environment
  - 1. Outdoor receptacles shall be weather resistant, GFCI type, in weather proof enclosure
  - 2.
- C. Coordination with Other Trades:
  - 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
  - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
  - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
  - 4. Install wiring devices after all wall preparation, including painting, is complete.
- D. Conductors:
  - 1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
  - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
  - 3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
  - 4. Existing Conductors:
    - a. Cut back and pigtail, or replace all damaged conductors.
    - b. Straighten conductors that remain and remove corrosion and foreign matter.
    - c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.
- E. Device Installation:
  - 1. Replace all devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
  - 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.

3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. Use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

F. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

G. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

H. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device, listing conditions in the written instructions.

I. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

J. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

### 3.3 GFCI RECEPTACLES

A. Provide GFCI receptacles in the following locations:

1. Bathrooms
2. Rooftops
3. Exterior
4. Within 6 feet of sinks
5. Mechanical/Janitor Rooms
6. Garages
7. Maintenance Shops

- 8. Locker Rooms
- 9. Kitchens

- B. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required. Where GFCI receptacles share a single circuit with other devices, a ground fault on any GFCI receptacle shall not interrupt power to downstream devices.

### 3.4 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."
- B. Identify each receptacle with panelboard identification and circuit number using machine printed labels suitable for environmental conditions.
- C. Essential Electrical System: Mark receptacles supplied from the essential electrical system to allow easy identification using a self-adhesive label.

### 3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. In healthcare facilities, prepare reports that comply with NFPA 99.
  - 2. Test Instruments: Use instruments that comply with UL 1436.
  - 3. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- B. Tests for Receptacles:
  - 1. Line Voltage: Acceptable range is 105 to 132 V.
  - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
  - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
  - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
  - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
  - 6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- C. Wiring device will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

### END OF SECTION

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## **SECTION 26 28 13**

### **FUSES**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Cartridge fuses rated 600 V ac and less for use in the following:
    - a. Control circuits.
    - b. Enclosed controllers.
    - c. Enclosed switches.
  - 2. Spare-fuse cabinets.

##### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
  - 1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
    - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
    - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
  - 2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified include any ambient temperature adjustment information.

#### 1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  - 1. Fuses: Equal to **10** percent of quantity installed for each size and type, but no fewer than **three** of each size and type.

#### 1.6 FIELD CONDITIONS

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

### **PART 2 - PRODUCTS:**

#### 2.1 MANUFACTURERS

- A. Subject to compliance with requirements provide products from one of the following or an approved equal:
  - 1. Bussmann
  - 2. Littlefuse
  - 3. Mersen
  - 4. Reliance
- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

#### 2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
  - 1. Type RK-1: 250 or 600-V, zero- to 600-A rating, 300 kAIC, dual element, time delay.
    - a. Dual element fuses shall have separate overload and short circuit elements.
  - 2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, time delay.
  - 3. Type J: 600-V, zero- to 600-A rating, 300 kAIC, time delay.

4. Type L: 600-V, 601- to 6000-A rating, 300 kAIC, time delay.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

### 2.3 SPARE-FUSE CABINET

- A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door with locking handle and key-coded cam lock and pull.
  1. Size: Adequate for storage of spare fuses specified with **15** percent spare capacity minimum. Minimum 24"W x 30"H x 12"D
  2. Finish: Gray, baked enamel.
  3. Identification: "SPARE FUSES" in 1-1/2-inch high letters on exterior of door.
  4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

## **PART 3 - EXECUTION:**

### 3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 FUSE APPLICATIONS

- A. Cartridge Fuses:

1. Service Entrance: Class L, time delay
2. Feeders: Class RK1, time delay equal to Bussman Low Peak LPS-RK.
3. Motor Circuits: Class RK1, time delay equal to Bussman Low Peak LPS-RK sized at 115% of motor full load current for 1.0 service factor motors and 125% for 1.15 service factor motors unless noted otherwise.
4. Large Motors (601-4000 A): Class L, time delay equal to Bussmann Low-Peak KRP-C sized at 150% to 200% of rating unless noted otherwise.
5. Elevator Branch Circuit: Class J, fast acting equal to Bussmann Low-Peak LPJ-SP
6. Other Branch Circuits: Class RK1, time delay
7. Control Transformer Circuits: Class CC, time delay, control transformer duty.

### 3.3 INSTALLATION

- A. No fuses shall be installed until the equipment installation is complete, including tests and inspections required prior to being energized. All fuses shall be of the same manufacturer to ensure retention of selective coordination, as designed.
- B. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- C. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Owner.

### 3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

**END OF SECTION**

## **SECTION 26 28 16**

### **ENCLOSED SWITCHES AND CIRCUIT BREAKERS**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Fusible switches.
  - 2. Non-fusible switches.
  - 3. Receptacle switches.
  - 4. Elevator Shunt trip switches.
  - 5. Molded-case circuit breakers (MCCBs).
  - 6. Enclosures.

##### **1.3 DEFINITIONS**

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

##### **1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
  - 1. Enclosure types and details for types other than NEMA 250, Type 1.
  - 2. Current and voltage ratings.
  - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
  - 4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

5. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
  - a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

**PART 2 - PRODUCTS:**

2.1 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with NFPA 70.

## 2.2 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Type HD, Heavy Duty, quick-make, quick-break operating handle and switch mechanism integral to box:
  - 1. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate fuses where indicated.
  - 2. Externally operable dual interlocked handle to prevent opening front cover with switch in ON position, or closing switch when door is open. Visible load interrupter knife switch blades in the off position with door open.
  - 3. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
  - 4. Lugs: front removeable and suitable of the number and size of conductors to which they will be connected. UL listed for 75°C aluminum or copper conductors.
  - 5. All current carrying parts shall be plated to resist corrosion.
  - 6. Service-Rated Switches: Labeled for use as service equipment.
- B. For receptacle switches provide interlocking linkage between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.
- C. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

## 2.3 ELEVATOR SHUNT TRIP SWITCHES

- A. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.
- B. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, with clips or bolt pads to accommodate fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- C. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses.
- D. Accessories:
  - 1. Key switch for key-to-test function.
  - 2. Red ON pilot light.
  - 3. Isolated neutral lug.
  - 4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
  - 5. Form C alarm contacts that change state when switch is tripped.
  - 6. Three-pole, double-throw, fire-safety and alarm relay; 24-V dc coil voltage.
  - 7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

## 2.4 MOLDED-CASE CIRCUIT BREAKERS

- A. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.
- B. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.
- C. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker.
- D. MCCBs shall be equipped with a device for locking in the isolated position.
- E. Lugs shall be suitable for 75 deg C rated wire.
- F. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.
- G. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal 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.
- H. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- I. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing.
- J. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- K. Features and Accessories:
  - 1. Standard frame sizes, trip ratings, and number of poles.
  - 2. Lugs: suitable for number, size, trip ratings, and conductor material.
  - 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
  - 4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
  - 5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.

6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

## 2.5 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: The enclosure shall be finished with the standard manufacturer gray finish.
- C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.
- D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.
- E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.
- F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

## **PART 3 - EXECUTION:**

### 3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
  1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

### 3.2 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings unless noted otherwise.
  - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
  - 2. Outdoor Locations: NEMA 250, Type 3R .
  - 3. Kitchen and Wash-Down Areas: NEMA 250, Type 4X.
  - 4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
  - 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
  - 6. Hazardous Areas: NEMA 250, Type 7 or Type 9.

### 3.3 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- C. Install fuses in fusible devices per equipment nameplate.
- D. Comply with NFPA 70 and NECA 1.

### 3.4 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
  - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  - 2. Label each enclosure with laminated-plastic nameplate.

### 3.5 FIELD QUALITY CONTROL

- A. Tests and Inspections:
  - 1. Perform each Visual, Mechanical, and electrical Inspection listed in NETA Acceptance Testing Specification (ATS). Certify compliance with test parameters:
  - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- B. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.
  - 1. Test procedures used.

2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

**3.6 ADJUSTING**

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges in accordance with the results of the power systems study.

**END OF SECTION**

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## **SECTION 262913**

### **MOTOR CONTROLLERS**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Manual motor controllers.
  - 2. Combination full-voltage magnetic motor controllers.
  - 3. Enclosures.
  - 4. Accessories.
  - 5. Identification.

##### **1.3 DEFINITIONS**

- A. CPT: Control power transformer.
- B. MCCB: Molded-case circuit breaker.
- C. MCP: Motor circuit protector.
- D. NC: Normally closed.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SCPD: Short-circuit protective device.

##### **1.4 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

- B. Shop Drawings: For each type of magnetic controller.
  - 1. Include plans, elevations, sections, and mounting details.
  - 2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
  - 3. Wire Termination Diagrams and Schedules: Include diagrams for signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
  - 4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- C. Product Schedule: List the following for each enclosed controller:
  - 1. Each installed magnetic controller type.
  - 2. NRTL listing.
  - 3. Factory-installed accessories.
  - 4. Nameplate legends.
  - 5. SCCR of integrated unit.
  - 6. For each combination magnetic controller include features, characteristics, ratings, and factory setting of the SCPD and OCPD.
    - a. Listing document proving Type 2 coordination.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For magnetic controllers to include in operation and maintenance manuals.
  - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
    - a. Routine maintenance requirements for magnetic controllers and installed components.
    - b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
    - c. Manufacturer's written instructions for setting field-adjustable overload relays.
    - d. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

## 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

## **PART 2 - PRODUCTS:**

### 2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following
  - 1. ABB
  - 2. Allen-Bradley
  - 3. Eaton
  - 4. Siemens
  - 5. Square D

### 2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.
- C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

### 2.3 MANUAL MOTOR CONTROLLERS

- A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle type for manual control of single or three phase motors up to 1HP where overload protection is not required or is provided separately; marked to show whether unit is off or on.
  - 1. Standard: Comply with NEMA ICS 2, general purpose, Class A.
  - 2. Configuration: Non-reversing unless noted otherwise on drawings.
  - 3. Flush or Surface mounting.
  - 4. Red pilot light where indicated.
- B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle type with integral overload protection for use with single phase motors up to 1HP; marked to show whether unit is off, on, or tripped.
  - 1. Configuration: Non-reversing unless noted otherwise on drawings.
  - 2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, **Class 10** tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; melting alloy type.
  - 3. Red pilot light where indicated on drawings.

4. HOA selector switch with dry contact inputs where indicated on drawings.

## 2.4 COMBINATION FULL-VOLTAGE MAGNETIC MOTOR CONTROLLER

- A. Description: Factory-assembled, combination full-voltage magnetic motor controller consisting of the controller described in this article, indicated disconnecting means, SCPD and OCPD, pushbuttons, selectors switches, and indicator lights in a single enclosure.
- B. Standard: Comply with NEMA ICS 2, general purpose, Class A.
- C. Configuration: Non-reversing unless noted otherwise on drawings.
- D. Contactor Coils: Pressure-encapsulated type with coil transient suppressors when indicated and assembled to allow inspection and replacement without disturbing the line or load wiring.
  1. Operating Voltage: Manufacturer's standard matching control power or line voltage.
- E. Contacts: Totally enclosed, double -break, silver alloy assembled to allow inspection and replacement without disturbing line or load wiring
- F. Control Power: obtain from integral CPT, with primary and secondary fuses, where no other power source is indicated. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.
- G. Solid-State Overload Relay:
  1. Switch or dial selectable for motor-running overload protection.
  2. Sensors in each phase.
  3. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
  4. Visible trip indicator with manual and remote reset function.
- H. Disconnecting Means:
  1. UL 98 and NEMA KS 1, heavy-duty, single throw, horsepower-rated, switch
  2. Switch mechanism shall be quick-make, quick-break, load break rated, such that during normal operation of the switch, the operation of the contacts shall not be capable of being restrained by the operating handle after the closing and opening action of the contacts has started.
  3. Provide clips or bolt pads to accommodate fuses in fusible switches.
  4. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
  5. Switch doors shall be interlocked with switch handle so that the door can only be opened when the switch is in the "OFF" (open) position.
- I. Auxiliary Control Devices: NEMA ICS5, factory installed in controller enclosure cover unless otherwise indicated.

1. Hand-Off-Auto Selector Switch
2. Start and Stop Pushbuttons
3. Red and Green Pilot Lights
4. Auxiliary Contacts: (2) Normally Closed and (2) Normally Open

## 2.5 ENCLOSURES

- A. Comply with NEMA 250, type designations for environmental conditions at installed location.
- B. The construction of the enclosures shall comply with NEMA ICS 6.
- C. Controllers in hazardous (classified) locations shall comply with UL 1203.
- D. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.
- E. All units shall be provided with internally mounted equipment ground kits and neutral kit where required; lugs shall be mechanical type suitable for number, size, and conductor material.

## 2.6 IDENTIFICATION

- A. Controller Nameplates: Laminated acrylic or melamine plastic signs, as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.
- B. Arc-Flash Warning Labels:
  1. Comply with requirements in Section 260573 "Power System Study

## **PART 3 - EXECUTION:**

### 3.1 EXAMINATION

- A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1
2. Outdoor Locations: NEMA 250, Type 3R
3. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel

### 3.3 INSTALLATION

- A. Comply with NECA 1.
- B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall with a minimum of (4) ¼-inch bolts or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems" unless otherwise indicated.
- C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70. Do not mount in inaccessible locations or where the passageway to the device may become obstructed.
- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- E. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.
  1. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping.
  2. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required)

### 3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

### 3.5 FIELD QUALITY CONTROL

- A. Perform Tests and Inspections:
  1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
  2. Visual and Mechanical Inspection:
    - a. Compare equipment nameplate data with drawings and specifications.
    - b. Inspect physical and mechanical condition.
    - c. Inspect anchorage, alignment, and grounding.
    - d. Verify the unit is clean.
    - e. Inspect contactors:

- 1) Verify mechanical operation.
    - 2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.
  - f. Motor-Running Protection:
    - 1) Verify overload element rating is correct for its application.
    - 2) If motor-running protection is provided by fuses, verify correct fuse rating.
  - g. Inspect bolted electrical connections for high resistance using one of the two following methods:
    - 1) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
  - h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
3. Electrical Tests:
  - a. Test motor protection devices according to manufacturer's published data.
  - b. Test circuit breakers as follows:
    - 1) Operate the circuit breaker to ensure smooth operation.
    - 2) For adjustable circuit breakers, adjust protective device settings according to the coordination study. Comply with coordination study recommendations.
  - c. Perform operational tests by initiating control devices.
- B. Motor controller will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

### 3.6 SYSTEM FUNCTION TESTS

- A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.
  1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
  2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
  3. Verify the correct operation of sensing devices, alarms, and indicating devices.

- B. Motor controller will be considered defective if it does not pass the system function tests and inspections.
- C. Prepare test and inspection reports.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain motor controllers.

**END OF SECTION**

## **SECTION 263213.16**

### **GASEOUS EMERGENCY ENGINE GENERATORS**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section includes packaged engine generators for emergency use with the following features:
  - 1. **Natural gas** engine.
  - 2. Gaseous fuel system.
  - 3. Control and monitoring.
  - 4. Generator overcurrent and fault protection.
  - 5. Generator, exciter, and voltage regulator.
  - 6. Outdoor engine generator enclosure.
  - 7. Vibration isolation devices.
  - 8. Finishes.
- B. Related Requirements:
  - 1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

##### **1.3 DEFINITIONS**

- A. EPS: Emergency power supply.
- B. EPSS: Emergency power supply system.
- C. LP: Liquid petroleum.
- D. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

#### 1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.
4. Include fuel consumption in cubic feet per hour (cubic meters per hour) at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include airflow requirements for cooling and combustion air in cubic feet per minute (cubic meters per minute) at 0.8 power factor, with air-supply temperature of 95, 80, 70, and 50 deg F (35, 27, 21, and 10 deg C). Provide Drawings indicating requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

#### 1.5 INFORMATIONAL SUBMITTALS

A. Sample Warranty.

#### 1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

- a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
- b. Operating instructions laminated and mounted adjacent to generator location.
- c. Training plan.

#### 1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
  1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
  2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
  3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
  4. Tools: Each tool listed by part number in operations and maintenance manual.

#### 1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer and has at least 5 years of successful installation experience with engine generator system installation work.

#### 1.9 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
  1. Warranty Period: 5 years from date of Substantial Completion.

### **PART 2 - PRODUCTS**

#### 2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products from one of the following:
  1. Caterpillar
  2. Cummins
  3. General
  4. Kohler
- B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

## 2.2 PERFORMANCE REQUIREMENTS

- A. B11 Compliance: Comply with B11.19.
- B. NFPA Compliance:
  - 1. Comply with NFPA 37.
  - 2. Comply with NFPA 70.
  - 3. Comply with NFPA 99.
  - 4. Comply with NFPA 110 requirements for Level [1] [2] EPSS.
- C. UL Compliance: Comply with UL 2200.
- D. Engine Exhaust Emissions: Comply with EPA requirements and applicable state and local government requirements.
- E. Noise Emission: Comply with **applicable state and local government requirements** for maximum noise level at **adjacent property boundaries** due to sound emitted by engine generator, including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.
- F. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
  - 1. Ambient Temperature: **5 to 104 deg F (Minus 15 to plus 40 deg C)**.
  - 2. Relative Humidity: Zero to 95 percent.
  - 3. Altitude: Sea level to **1000 feet (300 m)**.

## 2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

- A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- C. Service Load: as indicated on drawings.
- D. Power Factor: **0.8**, lagging.
- E. Frequency: 60 Hz.
- F. Voltage: **208**-V ac.
- G. Phase: Three-phase, **four**-wire.
- H. Induction Method: **Turbocharged**.
- I. Governor: Adjustable isochronous, with speed sensing.

- J. Mounting Frame: Structural-steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.
  - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.
- K. Capacities and Characteristics:
  - 1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries].
  - 2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- L. Engine Generator Performance:
  - 1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage, from no load to full load.
  - 2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
  - 3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency, from no load to full load.
  - 4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
  - 5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
  - 6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
  - 7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
  - 8. Start Time: Comply with NFPA 110, **Type 10**, system requirements.

## 2.4 ENGINE

- A. Fuel: **Natural gas**.
- B. Rated Engine Speed: 1800 rpm.
- C. Lubrication System: Engine or skid mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
  2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
  3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and with UL 499.
- E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.
1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
  2. Size of Radiator: Adequate to contain expansion of total system coolant, from cold start to 110 percent load condition.
  3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant-system pressure for engine used. Equip with gage glass and petcock.
  4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
  5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.
    - a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
    - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- F. Muffler/Silencer: Commercial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
1. Minimum sound attenuation of 12 dB at 500 Hz.
  2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be **90** dBA or less.
- G. Air-Intake Filter: **Standard**-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- H. Starting System: **[12] [24]**-V electric, with negative ground.
1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Performance Requirements" Article.

2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: **As required by NFPA 110 for system level specified.**
4. Battery: **Lead acid**, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least **three times** without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F (10 deg C) regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for **lead-acid** batteries. Unit shall comply with UL 1236 and include the following features:
  - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
  - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 to 140 deg F (minus 40 to plus 60 deg C) to prevent overcharging at high temperatures and undercharging at low temperatures.
  - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
  - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
  - e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
  - f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

## 2.5 GASEOUS FUEL SYSTEM

- A. Gas Train: Comply with NFPA 37.
- B. Engine Fuel System:

1. **Natural Gas**, Vapor-Withdrawal System:
  - a. Carburetor.
  - b. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
2. Fuel Filters: One for each fuel type.
3. Manual Fuel Shutoff Valves: One for each fuel type.
4. Flexible Fuel Connectors: Minimum one for each fuel connection.
5. Fuel change gas pressure switch.

## 2.6 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
- B. Provide minimum run-time control set for **15** minutes, with override only by operation of a remote emergency-stop switch.
- C. Comply with UL 508A.
- D. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.
- E. Control and Monitoring Panel:
  1. Digital controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
  2. Instruments: Located on the control and monitoring panel and viewable during operation.
    - a. Engine lubricating-oil pressure gage.
    - b. Engine-coolant temperature gage.
    - c. DC voltmeter (alternator battery charging).
    - d. Running-time meter.
    - e. AC voltmeter, **for each phase**.
    - f. AC ammeter, **for each phase**.
    - g. AC frequency meter.
    - h. Generator-voltage adjusting rheostat.

3. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication as required by NFPA 110 for Level 1 system, including the following:
  - a. Cranking control equipment.
  - b. Run-Off-Auto switch.
  - c. Control switch not in automatic position alarm.
  - d. Overcrank alarm.
  - e. Overcrank shutdown device.
  - f. Low water temperature alarm.
  - g. High engine temperature pre-alarm.
  - h. High engine temperature.
  - i. High engine temperature shutdown device.
  - j. Overspeed alarm.
  - k. Overspeed shutdown device.
  - l. Low-fuel main tank.
    - 1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for the duration required for the indicated EPSS class.
  - m. Coolant low-level alarm.
  - n. Coolant low-level shutdown device.
  - o. Coolant high-temperature prealarm.
  - p. Coolant high-temperature alarm.
  - q. Coolant low-temperature alarm.
  - r. Coolant high-temperature shutdown device.
  - s. EPS load indicator.
  - t. Battery high-voltage alarm.
  - u. Low-cranking voltage alarm.
  - v. Battery-charger malfunction alarm.
  - w. Battery low-voltage alarm.
  - x. Lamp test.
  - y. Contacts for local and remote common alarm.
  - z. Low-starting air pressure alarm.
  - aa. Low-starting hydraulic pressure alarm.
  - bb. Remote manual-stop shutdown device.
  - cc. Air shutdown damper alarm when used.
  - dd. Air shutdown damper shutdown device when used.
  - ee. Generator overcurrent-protective-device not-closed alarm.
- F. Remote Alarm Annunciator: Comply with NFPA 99. An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.
  1. Overcrank alarm.

2. Coolant low-temperature alarm.
  3. High engine temperature pre-alarm.
  4. High engine temperature alarm.
  5. Low lube oil pressure alarm.
  6. Overspeed alarm.
  7. Low-fuel main tank alarm.
  8. Low coolant level alarm.
  9. Low-cranking voltage alarm.
  10. Contacts for local and remote common alarm.
  11. Audible-alarm silencing switch.
  12. Air shutdown damper when used.
  13. Run-Off-Auto switch.
  14. Control switch not in automatic position alarm.
  15. Fuel tank derangement alarm.
  16. Fuel tank high-level shutdown of fuel supply alarm.
  17. Lamp test.
  18. Low-cranking voltage alarm.
  19. Generator overcurrent-protective-device not-closed alarm.
- G. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.
- H. Remote Emergency-Stop Switch: Flush; wall mounted unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

## 2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.
- B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.
1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
  2. Trip Settings: Selected to coordinate with generator thermal damage curve.
  3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
  4. Mounting: Adjacent to or integrated with control and monitoring panel.
- C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the

generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
  2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
  3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
  4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.
- D. Ground-Fault Indication: Comply with NFPA 70 Article 700, "Emergency System" signals for ground fault.
1. Indicate ground fault with other engine generator alarm indications.

## 2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide **12**-lead alternator.
- E. Range: Provide **broad** range of output voltage by adjusting the excitation level.
- F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- G. Enclosure: Dripproof.
- H. Instrument Transformers: Mounted within generator enclosure.
- I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.
1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
  2. Maintain voltage within 5 percent on one step, full load.
  3. Provide anti-hunt provision to stabilize voltage.

- 4. Maintain frequency within **5** percent and stabilize at rated frequency within **two** seconds.
- J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- L. Subtransient Reactance: **12** percent, maximum.

## 2.9 OUTDOOR ENGINE GENERATOR ENCLOSURE

- A. Description: Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
- B. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to 100 mph (160 km/h).
- C. Hinged Doors: With padlocking provisions.
- D. Space Heater: Thermostatically controlled and sized to prevent condensation.
- E. Lighting: Provide weather-resistant **LED** lighting with **30 fc (330 lx)** average maintained.
- F. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.
- G. Muffler Location: **Within** enclosure.
- H. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.
  - 1. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
  - 2. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.
- I. Interior Lights with Switch: Factory-wired, vapor proof luminaires within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
- J. Convenience Outlets: Factory-wired, GFCI. Arrange for external electrical connection.

## 2.10 VIBRATION ISOLATION DEVICES

- A. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
  - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch-(6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment-mounting and -leveling bolt that acts as blocking during installation.
  - 2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
  - 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
  - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  - 6. Minimum Deflection: 1 **inch (25 mm)**.
- B. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

## 2.11 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

## 2.12 SOURCE QUALITY CONTROL

- A. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
  - 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
  - 2. Test generator, exciter, and voltage regulator as a unit.
  - 3. Full-load run.
  - 4. Maximum power.
  - 5. Voltage regulation.
  - 6. Transient and steady-state governing.
  - 7. Single-step load pickup.
  - 8. Safety shutdown.
  - 9. Report factory test results within 10 days of completion of test.

### **PART 3 - EXECUTION**

#### **3.1 EXAMINATION**

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
- B. Examine roughing-in for piping systems and electrical connections to verify actual locations of connections before packaged engine generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

#### **3.2 INSTALLATION**

- A. Comply with NECA 1 and NECA 404.
- B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.
- C. Equipment Mounting:
  - 1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 03
  - 2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- E. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.
- F. Gaseous Fuel Piping:
  - 1. Natural gas piping, valves, and specialties for gas distribution are specified in Division 23."
- G. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

#### **3.3 CONNECTIONS**

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Gaseous Fuel Connections:

1. Connect fuel piping to engines with a gate valve and union and flexible connector.
2. Install manual shutoff valve in a remote location to isolate gaseous fuel supply to the generator.
3. Vent gas pressure regulators outside building a minimum of 60 inches (1500 mm) from building openings.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

E. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.4 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections **with the assistance of a factory-authorized service representative.**

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.

a. Visual and Mechanical Inspection:

- 1) Compare equipment nameplate data with Drawings and the Specifications.
- 2) Inspect physical and mechanical condition.
- 3) Inspect anchorage, alignment, and grounding.
- 4) Verify that the unit is clean.

b. Electrical and Mechanical Tests:

- 1) Perform insulation-resistance tests according to IEEE 43.
    - a) Machines Larger Than 200 hp (150 kW): Test duration shall be 10 minutes. Calculate polarization index.
    - b) Machines 200 hp (150 kW) or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.
  - 2) Test protective relay devices.
  - 3) Verify phase rotation, phasing, and synchronized operation as required by the application.
  - 4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
  - 5) Perform vibration test for each main bearing cap.
  - 6) Conduct performance test according to NFPA 110.
  - 7) Verify correct functioning of the governor and regulator.
2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
  3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
    - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    - c. Verify acceptance of charge for each element of the battery after discharge.
    - d. Verify that measurements are within manufacturer's specifications.
  4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
  5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
  6. Exhaust Emissions Test: Comply with applicable government test criteria.
  7. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
  8. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
- C. Coordinate tests with tests for transfer switches and run them concurrently.
- D. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

- E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
- F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
- G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- H. Remove and replace malfunctioning units and **retest** as specified above.
- I. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.
- J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

### 3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

**END OF SECTION**

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## **SECTION 263600**

### **TRANSFER SWITCHES**

#### **PART 1 - GENERAL**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section includes **automatic** transfer switches rated 600 V and less, including the following:
  - 1. Remote annunciator and control system.

##### **1.3 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
  - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
  - 2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.
- B. Shop Drawings:
  - 1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
  - 2. Include material lists for each switch specified.
  - 3. Single-Line Diagram: Show connections between transfer switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
  - 4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

##### **1.4 CLOSEOUT SUBMITTALS**

- A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
  - a. Features and operating sequences, both automatic and manual.
  - b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

## 1.5 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion.

## **PART 2 - PRODUCTS**

### 2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA ICS 1.
- C. Comply with NFPA 99.
- D. Comply with NFPA 110.
- E. Comply with UL 1008 unless requirements of these Specifications are stricter.
- F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- G. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
  1. Short-time withstand capability for **three** cycles.
- H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

- J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.
- K. Neutral Switching: Where four-pole switches are indicated, provide **neutral pole switched simultaneously with phase poles**.
- L. Neutral Terminal: Solid and fully rated unless otherwise indicated.
- M. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
- N. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable **with printed** markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."
  - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
  - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
  - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
  - 4. Accessible via **front** access.
- O. Enclosures: General-purpose NEMA 250, **Type 1**, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

## 2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

- A. Comply with Level 1 equipment according to NFPA 110.
- B. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
  - 1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
  - 2. Switch Action: Double throw; mechanically held in both directions.
  - 3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
  - 4. Conductor Connectors: Suitable for use with conductor material and sizes.
  - 5. Material: **Hard-drawn copper, 98 percent conductivity**.
  - 6. Main and Neutral Lugs: **Compression** type.
  - 7. Ground Lugs and Bus-Configured Terminators: **Compression** type.
  - 8. Ground bar.
  - 9. Connectors shall be marked for conductor size and type according to UL 1008.

- C. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.
  - 1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
  - 2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
  - 3. Fully automatic break-before-make operation with center off position.
  - 4. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.
- D. Electric **Nonautomatic** Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
- E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.
- F. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- G. Automatic Transfer-Switch Controller Features:
  - 1. Controller operates through a period of loss of control power.
  - 2. Undervoltage Sensing for Each Phase of Normal **and Alternate** Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
  - 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
  - 4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
  - 5. Test Switch: Simulate normal-source failure.
  - 6. Switch-Position Pilot Lights: Indicate source to which load is connected.
  - 7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
    - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
  - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
  - b. Push-button programming control with digital display of settings.
  - c. Integral battery operation of time switch when normal control power is unavailable.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.
- B. Identify components according to Section 260553 "Identification for Electrical Systems."
- C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.
- D. Comply with NECA 1.

#### **3.2 CONNECTIONS**

- A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary, to accommodate required wiring.
- B. Wiring Method: Install cables in raceways except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- F. Connect twisted pair cable according to Section 260523 "Control-Voltage Electrical Power Cables."
- G. Connect twisted pair cable according to Section 271513 "Communications Copper Horizontal Cabling."
- H. Route and brace conductors according to manufacturer's written instructions. Do not obscure manufacturer's markings and labels.
- I. Final connections to equipment shall be made with liquid tight, flexible metallic conduit no more than 18 inches (457 mm) in length.

### 3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections **with the assistance of a factory-authorized service representative**:
  1. After installing equipment, test for compliance with requirements according to NETA ATS.
  2. Visual and Mechanical Inspection:
    - a. Compare equipment nameplate data with Drawings and Specifications.
    - b. Inspect physical and mechanical condition.
    - c. Inspect anchorage, alignment, grounding, and required clearances.
    - d. Verify that the unit is clean.
    - e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
    - f. Verify that manual transfer warnings are attached and visible.
    - g. Verify tightness of all control connections.
    - h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:
      - 1) Use of low-resistance ohmmeter.
      - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.

- i. Perform manual transfer operation.
  - j. Verify positive mechanical interlocking between normal and alternate sources.
  - k. Perform visual and mechanical inspection of surge arresters.
  - l. Inspect control power transformers.
    - 1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
    - 2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
    - 3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.
3. Electrical Tests:
- a. Perform insulation-resistance tests on all control wiring with respect to ground.
  - b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
  - c. Verify settings and operation of control devices.
  - d. Calibrate and set all relays and timers.
  - e. Verify phase rotation, phasing, and synchronized operation.
  - f. Perform automatic transfer tests.
  - g. Verify correct operation and timing of the following functions:
    - 1) Normal source voltage-sensing and frequency-sensing relays.
    - 2) Engine start sequence.
    - 3) Time delay on transfer.
    - 4) Alternative source voltage-sensing and frequency-sensing relays.
    - 5) Automatic transfer operation.
    - 6) Interlocks and limit switch function.
    - 7) Time delay and retransfer on normal power restoration.
    - 8) Engine cool-down and shutdown feature.
4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
- a. Check for electrical continuity of circuits and for short circuits.
  - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
  - c. Verify that manual transfer warnings are properly placed.
  - d. Perform manual transfer operation.
5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.

- a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
    - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
    - c. Verify time-delay settings.
    - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
    - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
    - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
    - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
  - 6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
    - a. Verify grounding connections and locations and ratings of sensors.
  - B. Coordinate tests with tests of generator and run them concurrently.
  - C. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
  - D. Transfer switches will be considered defective if they do not pass tests and inspections.
  - E. Remove and replace malfunctioning units and retest as specified above.
  - F. Prepare test and inspection reports.
- 3.4 DEMONSTRATION
- A. **Engage a factory-authorized service representative to train** Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.
  - B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.
  - C. Coordinate this training with that for generator equipment.

**END OF SECTION**

## **SECTION 26 41 13**

### **LIGHTNING PROTECTION FOR STRUCTURES**

#### **PART 1 - GENERAL:**

##### **1.1 SUMMARY**

- A. Section includes lightning protection system for ordinary structures.
- B. Section includes lightning protection system for the following:
  - 1. Ordinary structures.
- C. This system provides facility protection for the building and occupants by preventing damage to the structure caused by lightning and induced transient currents.

##### **1.2 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
- B. Shop Drawings:
  - 1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
  - 2. Include raceway locations needed for the installation of conductors.
  - 3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
  - 4. Include roof attachment details, coordinated with roof installation warranty.
  - 5. Calculations required by NFPA 780 for bonding of metal bodies.

##### **1.3 INFORMATIONAL SUBMITTALS**

- A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - 1. Lightning protection cabling attachments to roofing systems and accessories.
  - 2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
  - 3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.
- B. Qualification Data: For Installer.

- C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.
- D. Sample Warranty.

#### 1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For lightning protection system to include in maintenance manuals.
  - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," and Section 260000 "General Requirements for Electrical Systems" include the following:
    - a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 017839 "Project Record Documents."
    - b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.
- B. Completion Certificate:
  - 1. **UL Master Label Certificate** suitable for fastening to building for display.

#### 1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Regularly engaged in manufacturer of lightning protection equipment, of types, sizes and ratings required, whose products have been satisfactorily used in similar service for not less than 5 years. The firm shall be a member of and certified by the Lightning Protection Institute of America.
- B. Installer Qualifications: A firm with at least 3 years of successful installation experience on projects with lightning protection work similar to that required for project
  - 1. The System Design shall be completed and the shop drawing stamped by an LPI Certified Master Installer – Designer of Lightning Protection Systems.
  - 2. The installing contractor shall be listed with the Lightning Protection Institute, and Underwriters' Laboratories, Inc.
  - 3. The installation contractor shall have personnel on staff Certified by the LPI as a Master Installer – Designer of lightning protection systems.
  - 4. LPI qualified staff, Journeyman or higher, shall provide on-site supervision of the installation.

#### 1.6 WARRANTY

- 1. The contractor shall furnish a 10-year adhesion warranty for all adhesives.

**PART 2 - PRODUCTS:**

2.1 MANUFACTURERS

- A. Erico
- B. Harger
- C. Thomas & Betts/Furse
- D. VFC/Lyncole

2.2 PERFORMANCE REQUIREMENTS

- A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for **Class I** materials on structures not exceeding 75ft and Class II materials on structures exceeding 75ft.
- B. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.
- C. Surge Suppression products for the electrical service entrance and communication services shall comply with NFPA 780 and UL 1449

2.3 MATERIALS

- A. Comply with minimum Class I and Class II material requirements as listed in NFPA 780.
- B. Air Terminals:
  - 1. **Aluminum** unless otherwise indicated.
  - 2. Safety tip.
  - 3. **Threaded base support:** Adhesive type for membrane roof, non-penetrating clamp for metal roof.
- C. Main and Secondary Conductors:
  - 1. **Aluminum smooth weave cable**
  - 2. Cable Fastener: Adhesive type for membrane roof, non-penetrating clamp for metal roof.
- D. Underground Conductors: **Stranded copper.**
- E. Ground Rods:
  - 1. Material: **Copper-clad steel.**
  - 2. Diameter: **3/4 inch.**
  - 3. Rods shall be not less than 120 inches long.

- F. Conductor Splices and Connectors for aboveground applications: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.
- G. Adhesives: High performance, solvent free, UV resistant, for durable bond with compatible substrate.

### **PART 3 - EXECUTION**

#### **3.1 INSTALLATION**

- A. Install lightning protection components and systems according to **NFPA 780**.
- B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.
- C. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for **concealed systems in NFPA 780**.
  - 1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
  - 2. Install conduit where necessary to comply with conductor concealment requirements.
  - 3. Structural elements and design features shall be used whenever possible to minimize the visual impact of exposed conductors.
  - 4. Coordinate sequence of installation with other trades to avoid coring, cutting, and patching.
- D. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- E. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.
- F. Install surge suppression at all power service entrances and at all entrances of conductive communications systems.

#### **3.2 CONNECTIONS**

- A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

- B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: **bolted connectors, exothermic weld, high compression, or crimp** type.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
  - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
  - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
- D. Follow manufacturer's temperature and substrate requirements for installation of adhesives.

### 3.3 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

### 3.4 FIELD QUALITY CONTROL

- A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
  - 1. Perform inspections as required to obtain a UL Master Label for system.
- B. Testing: Upon completion of installation of lightning protection system, test resistance-to-ground with resistance tester. Where tests show resistance-to-ground is over 25 ohms, take appropriate action to reduce resistance to 25 ohms, or less, by driving additional ground rods. Prepare test and inspection reports with corresponding test results and photos.

**END OF SECTION**

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## **SECTION 26 43 13**

### **SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section includes field-mounted and integrated SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

##### **1.3 REFERENCES**

- A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
  - 1. ANSI/IEEE C62.41.1, "Guide on the Surges Environment in Low Voltage (1000 V and Less) AC Power Circuits."
  - 2. ANSI/IEEE C62.41.2, "Recommended Practice on Characterization of Surges in Low Voltage (1000 V and Less) AC Power Circuits."
  - 3. ANSI/IEEE C62.45, "Guide on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits."
- B. Underwriters Laboratories, Inc. (UL):
  - 1. UL 1283, "Standard for Safety for Electromagnetic Interference Filters."
  - 2. UL 1449, "Standard for Surge Protective Devices."

##### **1.4 DEFINITIONS**

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.

- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.

## 1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
  - 2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.
- B. Sample Warranty

## 1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For SPDs to include in maintenance manuals.

## 1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.
  - 1. Warranty Period: Ten years from date of Substantial Completion.

## **PART 2 - PRODUCTS:**

### 2.1 GENERAL SPD REQUIREMENTS

- A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 1449 and UL 1283.
- C. MCOV of the SPD shall not be less than 115% of the nominal system voltage for 480Y/277V systems and 125% of the nominal system voltage for 208Y/120V systems.

- D. SPDs installed internal to the distribution equipment shall be of the same manufacturer as the equipment. The equipment shall be fully tested and certified in accordance with UL standards.

## 2.2 SUPPRESSORS

- A. SPDs: Comply with UL 1449, Type 1 for SPDs installed on the line side of the service entrance OCPD and Type 2 for SPDs installed on the load side of the service entrance OCPD. Type 2 SPDs shall also comply with UL 1283.
- B. SPDs shall be provided with the following features and accessories:
  - 1. Optional integral disconnect switch for externally mounted SPDs. SPDs integrated into factory supplied equipment shall have an input disconnect switch or circuit breaker unless indicated on the equipment drawings/data sheets.
  - 2. Internal fusing that disconnects the SPD before damaging internal suppressor components.
  - 3. Indicator light display for power and protection status with push-to-test capabilities.
  - 4. Audible alarm with silencing switch. Alarm shall activate when any one of the surge current modules has reached an end-of-life condition
  - 5. Form-C contacts, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
  - 6. Surge counter with reset switch reset and battery backup to retain memory upon loss of AC power.
- C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than the following values. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
  - 1. Category C, Service Entrance: 240 kA per phase, 120 kA per mode.
  - 2. Category B, Distribution: 160 kA per phase, 80 kA per mode.
  - 3. Category B, Branch: 120kA per phase, 60 kA per mode.
- D. Protection modes and UL 1449 VPR for grounded wye circuits shall not exceed the following:
  - 1. Line to Neutral: 1200 V for 480Y/277 V and 800 V for 208Y/120 V.
  - 2. Line to Ground: 1200 V for 480Y/277 V and 800 V for 208Y/120 V.
  - 3. Line to Line: 2000 V for 480Y/277 V and 1200 V for 208Y/120 V.
- E. SCCR: Per NEC 285.6, the short circuit current rating of the SPD shall be equal to or greater than the available short circuit current at the point on the system where installed.
- F. Inominal Rating:
  - 1. 20 kA for service entrance SPDs

2. 10kA for distribution/branch SPDs.

## 2.3 ENCLOSURES

- A. Indoor Enclosures for externally mounted SPDs: NEMA 250, Type 1.
- B. Outdoor Enclosures for externally mounted SPDs: NEMA 250, Type 3R or Type 4X.

## 2.4 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 1 and Class 2 Control Cables: Multiconductor cable with copper conductors, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

## **PART 3 - EXECUTION:**

### 3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install surge protection for low voltage electrical power circuits in accordance with reviewed product data, final shop drawings, manufacturer's written instructions and recommendations, and as indicated on the Drawings.
- C. Install a minimum 30A circuit breaker as required to comply with the UL listing of the SPD.
- D. Install SPDs with properly rated conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads.
- E. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
- F. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
- G. Twist input conductors together to reduce the input inductance.
- H. Use crimped connectors and splices only. Wire nuts are unacceptable.

### 3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections.
  - 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
  - 2. Inspect anchorage, alignment, grounding, and clearances.
  - 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

### 3.3 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

### 3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to operate and maintain SPDs.

## END OF SECTION

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## **SECTION 26 51 12**

### **LIGHTING**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General, Special and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. The Contractor is directed to examine each and every section of these specifications, all drawings relating to the Contract Documents, any and all Addenda, etc., for work described elsewhere that may relate to the provision of the work described herein. Materials and performance requirements are specified elsewhere herein that relate to these systems.
- C. Each Electrical Contractor's attention is directed to Section 260501 - General Provisions, Electrical, and all other Contract Documents as they apply to his work.

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Interior and Exterior Luminaires
  - 2. Exit Signs
  - 3. Lamps, Ballasts and Drivers
  - 4. Luminaire Supports and Accessories

##### **1.3 DESCRIPTION OF WORK**

- A. This work consists of providing all labor, materials, accessories, mounting hardware and equipment necessary for an operationally and aesthetically complete installation of all luminaires, including power wiring, control wiring and accessories, in accordance with the contract documents.
- B. Contractor shall coordinate with Vendors and other trades, in advance of installation work, to define all infrastructure and installation requirements. Contractor shall coordinate all infrastructure requirements with all approved lighting equipment prior to infrastructure installation. This includes, but not limited to, appropriately sized, positioned, and located junction boxes, structural supports, feeds, power conduits and control conduits, and remote code-compliant power-supply enclosures.[GR1]
- C. Contractor shall provide all luminaires, as herein specified, complete with lamps, drivers, power supplies, ballasts and accessories for safe and effective operation. All fixtures shall be installed and left in an operable condition with no broken, damaged or soiled parts.
- D. Contractor shall coordinate all infrastructure requirements with all approved lighting equipment prior to infrastructure installation, including, but not limited to appropriately sized, positioned and located junction boxes, structural supports, feeds, power and control conduits, and remote code-compliant power-supply enclosures.[GR2]

- E. All luminaires, items, equipment and parts furnished and specified herein shall bear the "UL Approved" label (or other NRTL label) to indicate compliance with UL requirements. All luminaires shall be manufactured in strict accordance with the appropriate and current requirements of the National Electrical Code as verified by Underwriters Laboratories, Inc. (UL), or tested to UL standards by other nationally recognized testing laboratory (NRTL) as acceptable to Building Officials and Code Administrators International (BOCAI); the International Conference of Building Officials (ICBO); or other relevant code authority recognized by the local jurisdiction within which the project is being constructed. Such a listing shall be provided for each luminaire type, and the appropriate label or labels shall be affixed to each luminaire in a location as required by code or law. All luminaires shall be UL/NRTL listed and labeled for installation in fireproof or non-fireproof construction, dry, damp, or wet locations, as required.[GR3]
- F. All available finishes and colors, for each luminaire, shall be submitted to the Architect for selection during shop drawing review. Premium finishes shall be provided at no additional cost premium.[GR4]
- G. Specifications and drawings are intended to convey all salient features, functions and characteristics of the luminaires only, and do not undertake to illustrate or set forth every item or detail necessary for the work.
- H. Minor details, not usually indicated on the drawings nor specified, but that are necessary for proper execution and completion of the luminaries, shall be included, the same as if they were herein specified or indicated on the drawings.
- I. The Owner, Architect and Engineer shall not be held responsible for the omission or absence of any detail, construction feature, etc. which may be required in the production of the light fixtures. The responsibility of accurately fabricating the light fixtures to the fulfillment of the specification rests with the Contractor.
- J. Where emergency battery packs are provided with fixtures (if any), they shall be connected to an un-switched power line and wired in accord with applicable codes and the manufacturer's recommendations.
- K. Refer to architectural details as applicable for recessed soffitt fixtures or wherever fixture installations depend upon work of other trades. Coordinate all installations with other trades. Verify dimensions of spaces for fixtures, and if necessary, adjust lengths to assure proper fit and illumination of diffuser and/or area below.
- L. Pre-manufactured flexible wiring systems are not permitted for this project.
- M. In accordance with the above and the criteria established herein, the Contractor is responsible for assuring the final design, fabrication and installation which fulfills the requirements of the Contract Documents.
- 1.4 CODES: Materials and installations shall be in accordance with the latest revision of the National Electrical Code and any applicable Federal, State and local codes and regulations.
- 1.5 REFERENCE STANDARDS: The publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. The publications may be referred to in the text by the basic designation only.[GR5]

- A. American National Standards Institute (ANSI):
  - 1. ANSI C62.41 - Recommended Practice in Low Power Circuits
  - 2. ANSI C78 Series - Physical and Electrical Characteristics of High-Intensity Discharge Lamps
  - 3. ANSI C78.377 - Specifications for the Chromaticity of Solid State Lighting Products
  - 4. ANSI C81 Series - Electric Lamp Bases and Holders
  - 5. ANSI C82.77 - Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment
  - 6. ANSI C136.21 (2004; R 2009) American National Standard for Roadway and Area Lighting Equipment - Vertical Tenons Used with Post-Top-Mounted Luminaires
  - 7. ANSI C136.3 (2005; R 2009) American National Standard for Roadway and Area Lighting Equipment Luminaire Attachments
  - 8. ANSI E1.20 - Remote Device Management Over DMX512 Networks
  - 9. ANSI/IES RP-16-10 - Nomenclature and Definitions for Illuminating Engineering
- B. ASTM International (ASTM)
  - 1. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
  - 2. ASTM B108/B108M - Standard Specification for Aluminum-Alloy Permanent Mold Castings
  - 3. ASTM B117 – Standard Practice for Operating Salt Spray (Fog) Apparatus
- C. Certified Ballast Manufacturers Association (CBM): Requirements for Ballast Certification.
- D. Federal Communications Commission (FCC):
  - 1. Code of Federal Regulations (CFR), Title 47, Part 18
  - 2. Part 15 Class B: Radio Frequency Devices, Commercial Rated
- E. Entertainment Services and Technology Association: ESTA E1.3 - Entertainment Technology - Lighting Control System - 0 to 10V Analog Control Protocol
- F. International Electrotechnical Commission (IEC):
  - 1. IEC 61000-3-2 - Harmonic Current Emissions
  - 2. IEC 61347-1 - General and Safety Requirements for Lamp Control Gear
  - 3. IEC 61347-2-13 - Particular Requirements for Electronic Control Gear for LED Modules
  - 4. IEC 61547 - EMC Immunity Requirements
  - 5. IEC 62384 - DC and AC Supplied Electronic Control Gear for LED Modules - Performance Requirements
  - 6. IEC 62386-101 - Digital Addressable Lighting Interface - Part 101: General Requirements – System
  - 7. IEC 62386-102 - Digital Addressable Lighting Interface - Part 102: General Requirements - Control Gear
  - 8. IEC 62386-207 - Digital Addressable Lighting Interface - Part 207: Particular Requirements for Control Gear - LED Modules (device type 6)
- G. Illuminating Engineering Society of North America (IESNA):

1. IES HB-10, IES Lighting Handbook – Tenth Edition
  2. IES Approved Method for Electrical and Photometric Measurements of General Service Incandescent Filament Lamps, LM-45.
  3. IES Approved Method for Photometric Testing of Indoor Luminaires Using High Intensity Discharge Lamps, LM-46.
  4. IES Approved Method for Life Testing of High Intensity Discharge Lamps, LM-47.
  5. IES Approved Method for Life Performance Testing of General Lighting Incandescent Filament Lamps, LM-49.
  6. IES Approved Method for Photometric Measurements of High Intensity Discharge Lamps, LM-51.
  7. IES ANSI Approved Standard File Format for Electronic Transfer of Photometric Data and Related Information, LM-63.
  8. IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products, LM-79.
  9. IES Approved Method for Measuring Lumen Maintenance of LED Light Sources, LM-80.
  10. IES Approved Method for the Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a Function of Temperature, LM-82.
  11. IES Projecting Long Term Lumen Maintenance of LED Light Sources, TM-21.
  12. IES RP-8 – Roadway Lighting
- H. Institute of Electrical and Electronic Engineers (IEEE): C62.41-91 - Recommended Practice on Surge Voltage in Low Voltage AC Power Circuits
- I. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electrical Code (NEC), National Fire Protection Association
  2. NFPA 101 - Life Safety Code, National Fire Protection Association
- J. National Electrical Manufacturer's Association (NEMA):
1. NEMA FA1, - Outdoor Flood Lighting Equipment
  2. NEMA SH5, - Tubular Steel, Aluminum and Prestressed Concrete Roadway Lighting Poles
  3. NEMA SSL1 - Electronic Drivers for LED Devices, Arrays, or Systems
  4. NEMA SSL3- High-Power White LED Binning for General Illumination
  5. NEMA SSL7A - Phase Cut Dimming for Solid State Lighting: Basic Compatibility
  6. NEMA 410 - Performance Testing for Lighting Controls and Switching Devices with Electronics
  7. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
- K. OSHA 29CFR1910.7 – Luminaires shall be listed by National Recognized Testing Laboratory Approved by United States Department of Labor.
- L. Underwriters Laboratories, Inc. (UL):
1. Underwriters Laboratories (UL) Standards
  2. Underwriters Laboratories (UL) Standard for Class 2 Power Units
  3. Underwriters Laboratories Safety Standard for Light Emitting Diode (LED) Equipment for Use in Lighting Products, UL 8750
  4. Underwriters Laboratories (UL) Standard for Safety Class 2 Power Units, UL 1310
  5. Underwriters Laboratories (UL) Standard for Luminaires, UL 1598

6. Underwriters Laboratories (UL) Standard for Emergency Lighting and Power Equipment, UL 924

#### 1.6 ACRONYMS AND DEFINITIONS

- A. CCT: Correlated color temperature
- B. CRI: Color-rendering index. A measure of the degree of color shift that objects undergo when illuminated by a lamp, compared with those same objects when illuminated by a reference source of comparable correlated color temperature (CCT)
- C. CU: Coefficient of utilization
- D. IECC: International Energy Conservation Code
- E. LER: Luminaire efficacy rating, which is calculated according to NEMA LE 5.
- F. Lumen: Delivered output of luminaire.
- G. Light Fixture (Luminaire): Complete lighting unit consisting of a lamp(s) and driver(s)/ballast(s) (when applicable) together with the parts designed to distribute the light, to position and protect the lamp(s), and to connect the lamps to the power supply.
- H. Pole: Luminaire support structure, including tower used for large area illumination.
- I. NRTL: Nationally Recognized Testing Laboratory
- J. SPD: Surge Protection Device
- K. Standard: Same definition as "Pole" above.
- L. RCR: Room cavity ratio.
- M. UL: Underwriters Laboratory
- N. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.
- O. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

#### 1.7 EQUAL MANUFACTURERS[GR6]

- A. Manufacturers listed as "Equal" to the Basis of Design on the light fixture schedule shall submit product cutsheets to the Engineer ten (10) days prior to bid for final written approval. This written approval will only be issued in addendum form. "Equal" fixtures shall be of equal or better quality and performance to the fixture(s) listed with manufacturer's model numbers. Burden of proof shall be on the Contractor, Vendor and manufacturer.
- B. Upon request by Engineer, the Contractor shall submit manufacturer's computerized horizontal illumination levels using AGI32 software in footcandles at workplane (30" above finished floor), taken every 3 feet in every room and area. Include average maintained footcandle levels and maximum and minimum ratio.
- C. Upon request by Engineer, the Contractor shall submit manufacturer's computerized horizontal illumination levels using AGI32 software in footcandles, taken every ten (10) feet for the entire site. Include average maintained footcandle levels and maximum and minimum ratio.

#### 1.8 SUBMITTALS

- A. Submittal data shall be in accordance with Division 01 SUBMITTAL Specification Section, IECC and as specified herein.[GR7]
- B. Eight (8) copies of light fixture factory shop drawings and cuts, showing fixture dimensions, photometric data and installation data shall be submitted to the Engineer for review 15 days after project award date. (Verify shop drawing quantities with the Architect.)
- C. Data, drawings and reports shall employ the terminology, classifications and methods prescribed by IESNA HB-10, as applicable, for the lighting system specified.
- D. When catalog data and/or shop drawings for luminaires are submitted for approval, photometric data from an independent testing laboratory or one participating in the NIST National Voluntary Laboratory Accreditation Program (NVLAP) shall be included with the submittal, indicating average brightness and efficiency of the luminaire specified in specification or as shown on the drawings. Coefficient of utilization data is unacceptable.[GR8]
- E. Product data lacking sufficient detail to indicate compliance with contract documents will be rejected.
- F. Product Data: For each type of lighting fixture, arranged in order of fixture designation. For each type, include data on features, accessories, finishes, and the following:
  - 1. Physical description of lighting fixture including dimensions.
  - 2. Emergency lighting units including battery and charger.
  - 3. All available finishes and colors for each luminaire type shall be submitted to the Architect for selection during review.
  - 4. Life, output (lumens, CCT, and CRI), and energy-efficiency data for light fixtures.
  - 5. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
  - 6. Dimensions, effective projected area (EPA), accessories, installation details and construction details.
  - 7. Poles: Include dimensions, wind load determined in accordance with AASHTO, pole deflection, pole class, and other applicable information.
  - 8. Distribution data according to IESNA classification type as defined in IESNA HB-10.
  - 9. Amount of shielding on luminaires.
  - 10. Warranty[GR9].
- G. Shop Drawings: Including plans, elevations, sections, details, and attachment to other work.
  - 1. Include detailed equipment assemblies and indicate electrical ratings, dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
- H. Sample Submittals:

1. The Contractor shall furnish components, partial mock-ups, operational samples and/or one complete luminaire for each type so designated as requiring such for submittal(s).
  2. Review samples shall be made from same parts to be used on project luminaires.
  3. Restoration and custom luminaire Manufacture(s) shall provide access to the factory for Owner, Architect and Engineer to review work in progress and to review partial and complete luminaire mock-ups as identified.
- I. Pole and Support Component Certification Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-5 and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.

#### 1.9 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 and NEMA unless more stringent requirements are specified or indicated.
- D. Where groups of luminaire types exhibit the same list of acceptable Manufacturers, such as downlights, accents, and wallwashers, the intent is to have a final installation with the same Manufacturer's equipment across the groupings as specified for consistency of optics, aesthetics, and similarity of maintenance procedures. Mixing/matching across groups is unacceptable. This also applies to multi-phased projects with single or multiple, but related luminaire types exhibiting the same list of acceptable Manufacturers, except where products have subsequently been discontinued or significantly redesigned in size, appearance, lamping, or gear.
- E. Comply with IEEE C2, "National Electrical Safety Code."
- F. Comply with NFPA 70.

#### 1.10 COORDINATION

- A. Coordinate layout and installation of lighting fixtures with all other construction including geothermal well field, sanitary, storm and domestic water.
- B. Coordinate layout and installation of lighting fixtures with all other construction that penetrates ceilings or is supported by them, including HVAC equipment, plumbing, fire-suppression system and partition assemblies. Refer to Architects reflected ceiling plan (RCP) for locations of all ceiling devices.

#### 1.11 PRODUCT DELIVERY, STORAGE AND HANDLING:

- 1.12 The Contractor shall provide, receive, unload, uncrate, store, protect and install lamps, luminaires and auxiliary equipment, as specified herein, in accordance with respective manufacturers' project conditions of temperature and humidity and with appropriate protection against dust and dirt. Lamps for miscellaneous equipment shall be provided and installed by the Contractor according to equipment manufacturers' guidelines. All products shall be stored in manufacturer's unopened packaging until ready for installation.
- A. Package aluminum poles for shipping according to ASTM B 660.
  - B. Luminaire Poles: Do not store poles on ground. Support poles so they are at least one foot above ground level and growing vegetation. Support poles to prevent distortion and arrange to provide free air circulation. Do not remove factory-applied pole wrappings until just before installing pole.
  - C. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.
- 1.13 EXTRA MATERIALS
- A. Furnish the following extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing content:
    - 1. Single Sided Exit Sign: Furnish at least five (5) of each type.
    - 2. Double Sided Exit Sign: Furnish at least five (5) of each type.
    - 3. LED Drivers: One (1) for every fifty (50) of each type and rating installed. Furnish at least five (5) of each type.
    - 4. LED Lamps/Boards: One (1) for every one-hundred (100) of each type and rating installed. Furnish at least two (2) of each type.
- 1.14 WARRANTIES
- A. The equipment items shall be supported by service organizations which are reasonably convenient (less than 100 miles from project site) to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.
  - B. All luminaries, finishes, poles and all of its component parts, workmanship, and controls shall have an unconditional five (5) year on-site replacement warranty. Warranty shall include all light fixtures, lamps, drivers, poles, finishes and all components to be free from defects in materials and workmanship for a period of five (5) years from date of Owner's acceptance. On-site replacement includes transportation, removal, and installation of new products. Replacement of luminaries, faulty materials and the cost of labor to make the replacement shall be the responsibility of the Contractor.
  - C. The Warranty specified in this Article shall not deprive the Owner of other rights the Owner may have under provisions of the Contract Documents and shall be in addition to and run concurrently with other warranties made by the Contractor under requirements of the Contract Documents.
  - D. LED drivers: The warranty period shall not be less than ten (10) years from the date of substantial completion. The warranty shall state the malfunctioning LED driver shall be exchanged by the manufacturer and promptly shipped to the Owner. The replacement

LED driver shall be identical to, or an improvement upon, the original design of the malfunctioning LED driver.

- E. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
  - 1. Warranty Period for Metal Corrosion: Five (5) years from date of Substantial Completion.
  - 2. Warranty Period for Color Retention: Five (5) years from date of Substantial Completion.
  - 3. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than five years from date of Substantial Completion.

#### 1.15 SYSTEM COMMISSIONING

- A. Section 019113 requires the engagement of a Commissioning Authority to document the completion of the Mechanical, Fire Protection, Plumbing, Electrical, Electronic Safety and Security, and associated Control Systems for the project. Section 019113 defines the roles and responsibilities of each member of the commissioning team.
- B. Comply with the requirements of Section 019113 for the commissioning of the various building systems.

### **PART 2 - PRODUCTS:**

#### 2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply for product selection:
  - 1. Manufacturers: Subject to compliance with requirements, provide one of the approved products indicated on the Light Fixture Schedule.
- B. Subject to compliance with requirements, provide one of the products indicated on Light Fixture Schedule. Refer to Light Fixture Schedule for manufacturers and model numbers. Basis of Design for each light fixture type shall be the first fixture manufacturer and model number for each type listed. Refer to Specification Section 260501, paragraph EQUAL MANUFACTURERS for additional requirements.
- C. Manufacturer's catalog numbers together with the descriptions on the drawings and these specifications are indicative of required design, appearance, quality and performance. Refer any discrepancies between any of these to the Engineer for resolution prior to bid. In absence of such notice to the Engineer, provide the greater requirement as directed by the Engineer, without additional cost.
- D. All luminaires shall be DLC (Design Lights Consortium) Certified.
- E. The lighting equipment specified herein has been carefully chosen for its ability to meet the luminous environment requirements of this project. Calculations (with AGI32 or other such software) are generally performed to determine luminances, luminance ratios, and horizontal and vertical illuminances and respective ratios and to assess

glare and reflected glare. In some instances, virtual reality “images” have been generated (with AGi32 or other such software) to assist the Lighting Designer, the Architect and/or the Owner in assessing the lighting quality of the space(s). Equipment and/or manufacturers which have been shown to comply with established criteria, including ASHRAE/IES 90.1 and IES guidelines and normal-power lighting requirements as applicable by ordinance, code, Federal law, mandate, or directive, and/or intended LEED certification or other building-rating system, and other lighting standards as deemed appropriate for this specific project is specified herein.

## 2.2 GENERAL REQUIREMENTS FOR LUMINAIRES AND COMPONENTS

- A. Comply with the requirements specified in the Articles below and the Light Fixture Schedule.
- B. Complete luminaires shall be in accordance with NFPA 70, NEMA, and UL 1598 listed and labeled.
- C. Provide luminaires complete with lamps of number, type, and wattage indicated.
- D. Ballasts, drivers, or transformers, unless otherwise specified, shall be field replaceable and shall be serviceable while the fixture is in its normally installed position, and shall not be mounted to removable reflectors or wireway covers unless so specified.
- E. Unless otherwise specified, a dedicated means of connecting light source to power shall be used in all luminaires unless otherwise specified and shall meet all UL requirements. LED modules shall be field replaceable.
- F. Recessed fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- G. Luminaires shall be entirely factory wired by the luminaire manufacturer in accordance with code and UL requirements and shall be furnished fully compatible with the project electrical wiring and controls system for smooth, continuous, dimming or on/off flicker-free operation.
- H. Provide in-line fuse-holders with fuses sized per manufacturer’s recommendation for each fixture.
- I. Exterior building mounted light fixtures shall be UL classified for damp or wet locations as applicable and shall be complete with gaskets, cast aluminum outlet box and grounding. All dissimilar metal materials shall be separated by non-conductive materials to prevent galvanic action.
- J. Provide all luminaires with a specific means for grounding their metallic wireways and housings to an equipment grounding conductor and ground accordingly upon installation.
- K. All luminaires shall be provided with a ground wire and grounded accordingly upon installation.
- L. All luminaires supplied for recessing in suspended ceilings shall be supplied with pre-wired junction boxes, unless otherwise specified.
- M. Provide “maximum wattage label” on all light fixture based on the specified maximum wattage indicated on the light fixture schedule.
- N. Metal parts: Free of burrs, sharp corners and sharp edges.

- O. Doors, frames and other internal access: Smooth operating, free of light leakage under operating conditions. Designed to prevent doors, frames, lenses, diffusers and other components from falling accidentally during maintenance and when secured during operating position.
- P. Mounting Frames and Rings: If ceiling system and luminaire type requires, each recessed and semi-recessed luminaire shall be furnished with a mounting frame or ring compatible with the ceiling in which they are to be installed as coordinated by Contractor. The frames and rings shall be one piece and of sufficient size and strength to sustain the weight of the luminaire and maintain plumb.
- Q. Pendant Supports: Contractor shall be responsible for coordination with Manufacturer, Architect, Structural Engineer and related trades to ensure that proper and adequate structural reinforcement is provided within ceilings to support pendant mounted lighting equipment for a secure, neat, square, plumb appearance. Pendants shall not sag, droop, snake or otherwise appear out of plumb or alignment in finished installation with lamps, globes, lenses, lens frames or doors etc. in place.
- R. Wall Bracket (Sconce) Supports: Contractor shall be responsible for coordination with Manufacturer, Architect, Structural Engineer and related trades to ensure that proper and adequate structural reinforcement is provided within walls to support wall mounted lighting equipment for a secure, neat, square, plumb appearance. Wall brackets shall not sag, droop, snake or otherwise appear out of plumb or alignment in finished installation with lamps, globes, lenses, lens frames or doors etc. in place.
- S. All lenses or other light diffusing elements shall be removable for access to lamp and electrical and electronic components and luminaire cleaning, however, they must otherwise be positively and securely held in-place, unless otherwise specified.
- T. There shall be no light leaks between the lens and the lens frame. All lens door or holder trim flanges shall fit plumb and flush with the ceiling or wall surface. There shall be no light leaks around the interface between lens door or holder trim flanges and the ceiling or wall.
- U. Unless otherwise specified, a dedicated means of connecting light source to power shall be used in all luminaires unless otherwise specified and shall meet all UL requirements. LED modules shall be field replaceable.
- V. Recessed luminaires mounted in an insulated ceiling shall be listed for use in insulated ceilings or provisions made to maintain code-compliant air-space around luminaires in accordance with Manufacturers' instructions.
- W. Mechanical Safety: Unless otherwise specified, luminaire closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, captive hinges or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.
- X. Unless otherwise specified, luminaires with louvers or light transmitting panels shall have hinges, latches and safety catches to facilitate safe, convenient cleaning and relamping. Vapor tight luminaires shall have stainless steel pressure clamping devices in lieu of the latches.
- Y. Yokes, brackets and supplementary supporting members necessary for mounting lighting equipment shall be furnished and installed by the Contractor and approved by the Architect. All materials, accessories, and any other equipment necessary for the

complete and proper installation of luminaires, lamps, ballasts/neon transformers included in the contract shall be furnished and installed by the Contractor. All yokes, brackets and supplementary supports shall provide a neat, square, plumb and level appearance, and shall not sag, droop, snake or otherwise appear out of plumb or alignment in finished installation with all lamps, globes, lenses, lens frames or doors etc. in place.

- Z. All connections shall be fixed rigid by screws, rivets and/or soldering. Screws and rivets shall not be visible except as necessary for maintenance and/or aesthetic appearance. Soldering shall be ground smooth to a clean, contiguous surface. All connections shall provide a neat, square, plumb and level appearance, and shall not sag, droop, snake or otherwise appear out of plumb or alignment in finished installation with lamps, globes, lenses, lens frames or doors etc. in place.
- AA. All sheet metal work shall be free from tool marks and dents and shall have accurate angles bent as sharp as compatible with the gauges of the required metal and the luminaire styling. All intersections and joints shall be formed true and of adequate strength and structural rigidity to prevent any distortion after assembly.
- BB. For steel and aluminum luminaires, all screws, bolts, nuts and other fastening and latching hardware shall be a cadmium or equivalent plated. For stainless steel luminaires, all hardware shall be stainless steel. For all bronze luminaires, all hardware shall be bronze.
- CC. Extruded aluminum frames and trims shall be rigid and manufactured from quality aluminum without blemishes in the installed product. Miter cuts shall be accurate; joints shall be flush and without burrs and cut alignment maintained with the luminaire located in its final position.
- DD. Castings shall exactly replicate the approved pattern(s) and shall be free of sand pits, blemishes, scales and rust and shall be smoothly finished, excepted as necessary for an authentic historic appearance and as agreed by Architect. Tolerances shall be provided for any shrinkage in order that the finished castings accurately fit their locations resulting in plumb and level fit and consistently tight-seamed fittings.
- EE. Outdoor Luminaires: Luminaires shall be suitably gasketed and vented according to manufacturer's instructions. All dissimilar metal materials shall be separated by non-conductive materials to prevent galvanic action.
- FF. Luminaires in Hazardous Areas: Luminaires shall be suitable for installation in flammable atmospheres (Class and Group) as defined in NFPA 70 and shall comply with UL 844.
- GG. Product procurement and coordination: Contractor shall:
  - 1. Order products according to application
  - 2. Confirm the proper and complete catalog number with distributor and agent.
  - 3. Ensure wiring, driver, etc meets the specifications and proper requirements.
  - 4. Provide additional parts and pieces required to complete the installation in the location and manner intended by the design.
- HH. Each light fixture shall be packaged with complete instructions and illustrations on how to install.

- II. Each light fixture box, container, etc shall be labeled at the factory with the type designation as indicated on the Light Fixture Schedule.
- JJ. Fixture whips shall be 1/2" flexible, with clamp-on steel fittings at each end, six-foot maximum length, with insulated throat bushings at each end and bonding locknuts. Wiring thru fixture whips shall be #12 AWG, with #12 AWG ground bonded to outlet at source end.
- KK. All luminaires that are split-wired shall be provided with a permanently affixed lamacoid warning label on the ballast channel cover indicating two hot circuits present and indicating both normal and emergency power panel and circuit numbers.
- LL. Confirm all finishes and mounting heights with Architect during shop drawing review.
- MM. Provide custom, factory cut stem lengths as required.
- NN. Contractor shall verify ceiling types prior to ordering fixtures and provide fixtures appropriate to the actual condition. This is to include specific type of lay-in ceiling grid.
- OO. Exit signs and fixtures that are hatched or where the fixture type contains the suffix "E" for emergency operation, the fixture shall have an integral 90-minute battery inverter if not powered from an emergency generator.
- PP. All emergency powered fixtures shall have test switches factory installed integral to the reflector. Remote test switches will not be accepted.

## 2.3 LUMINAIRE REFLECTORS AND TRIMS

- A. Alzak cones, reflectors, baffles and louvers shall be warranted against discoloration.
- B. All cones, reflectors, baffles and louvers shall be removable for lamp access and luminaire cleaning; however, they must otherwise be positively and securely held in place.
- C. All trims, reflectors and canopies shall fit snugly and securely to the ceiling or wall so that no light leak occurs.
- D. Trims shall be self-flanged and white, unless otherwise specified.
- E. For trimless or flangeless luminaires, Contractor shall coordinate with other Trades to achieve a trimless/flangeless installation acceptable to the Architect. Where ceilings are drywall or plaster, this involves Level 5 finishes or as otherwise directed by the Architect. In drywall, plaster, wood, or stone ceilings, special luminaire collars and exacting coordination are required of Contractor.

## 2.4 LIGHT EMITTING DIODE (LED) ELECTRONIC DRIVERS: The electronic driver shall at a minimum meet the following characteristics:

- A. LED drivers shall comply with NEMA SSL 1, NFPA 70, and UL 8750 unless otherwise specified.
- B. All LED luminaires shall use drivers integral to luminaires or as otherwise required by the luminaire manufacturer.
- C. Drivers remote from luminaires shall be housed in NEMA enclosures so rated for the driver and located in code-compliant, sound-isolated, well-ventilated and easily accessible areas. Wire shall be sized according to run length and LED Manufacturer's size and distance-of-run requirements and all in accordance with all code requirements.

- D. Driver shall comply with UL 1310 Class 2 requirements for dry and damp locations, NFPA 70 unless specified otherwise. Drivers shall be designed for the wattage of the LEDs used in the indicated application. Drivers shall be designed to operate on the voltage system to which they are connected.
  - E. LED driver shall withstand up to a 1,000-volt surge without impairment of performance as defined by ANSI C62.41 Category A.
  - F. LED driver shall tolerate  $\pm 10$  percent supply voltage fluctuation with no adverse effects to driver or LEDs.
  - G. LED driver forward voltage ( $V_f$ ) shall be matched to LED board.
  - H. LED driver shall exhibit no visible change in light output with a variation of  $\pm 10$  percent line voltage input.
  - I. Drivers for luminaires controlled by dimming devices shall be as specified herein and equipped for dimming and conform to the recommendations of the manufacturer of the associated dimming devices to assure satisfactory operation of the lighting system. Contractor shall coordinate all wiring infrastructure to accommodate final-selected drivers and controls systems for smooth, continuous, and flicker-free operation.
  - J. Flicker: The flicker shall be less than 5 percent at all frequencies below 1000 Hz and without visible flicker.
    - 1. Drivers shall meet or exceed NEMA 410 driver inrush standard.
  - K. Power factor shall be 0.95 (minimum).
  - L. Class A Sound Rating.
  - M. Current crest Factor of 1.5 or less.
  - N. LED driver total harmonic distortion (THD) shall be less than 20 percent for drivers unless otherwise specified. For dimming drivers, THD shall at no point in the dimming curve allow imbalance current to exceed full output THD.
  - O. All LED luminaires shall be fused on the primary side of the driver as recommended by the respective luminaire manufacturers.
  - P. All LED drivers shall be suitably sized to accommodate the LED array consistent with industry standards, including IEC standard 60929 Annex E.
- 2.5 LIGHT EMITTING DIODE (LED): The light emitting diodes shall as a minimum meet the following characteristic:
- A. LED modules shall be manufactured by Cree, GE, Philips, Osram, Niche, or Xicato.
  - B. LED lamps shall comply with ANSI C78.1.
  - C. Chromacity of LED lamps shall comply with ANSI C78.377A and NEMA SSL-3.
  - D. Light emitting diodes shall be tested under IES LM-80 standards.
  - E. Color Rendering Index (CRI) shall be 84 (minimum).
  - F. Color temperature of 3,500K[GR11], or as indicated on light fixture schedule.
  - G. Rated lumen maintenance of 90% lumen output at 50,000 hours (minimum).
  - H. Rated lumen maintenance of 70% lumen output at 100,000 hours (minimum).

- I. Provide light fixture types that the [GR12]LED boards and drivers can[GR13] be replaced from the bottom and below ceiling. Trim for the exposed surface of flush-mounted fixtures shall be white or as indicated on light fixture schedule.
- J. For color consistency, lamp maintenance consistency and for light output consistency, mixed lamps[GR14] of the same lamp type from different manufacturers is unacceptable. Use the same brand and date code for all lamps [GR15]except as otherwise specified. Contractor shall be responsible for coordinating all lamps and brand among all luminaire Vendor(s) and Contractor's respective distributor(s).

## 2.6 SUSPENDED LUMINAIRES

- A. Provide hangers capable of supporting twice the combined weight of fixtures supported by hangers. Provide with swivel hangers to ensure a plumb installation. Hangers shall be cadmium-plated steel with a swivel-ball tapped for the conduit size indicated. Hangers shall allow fixtures to swing within an angle of 45 degrees. Brace pendants 4 feet or longer to limit swinging. Single-unit suspended fixtures shall have twin-stem hangers. Multiple-unit or continuous row fixtures shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end. Rods shall be a minimum 0.18 inch diameter.
- B. All suspended luminaires with a weight in excess of 150 pounds shall be fitted with safety cable of sufficient strength and length to meet all UL safety cable load-bearing requirements. Cable shall exhibit a finish (but not painted) compatible with that of the metal finish of the stem/chain/suspension-cable assembly or alternatively finished in black as approved by Architect. Shop drawings shall indicate luminaire weight. Contractor shall coordinate structural support/attachment requirements including independent structure for safety cable attachment with Vendor, Architect, and Structural Engineer and all respective trades. Safety cable shall exhibit sufficient length to wrap tightly and entirely around structural member at least twice before attachment subject to Vendor confirmation of UL requirements and pending Structural Engineer review. Contractor shall provide labor necessary for the stem/chain-assembly-wiring-threading and safety-cable-attachment as instructed by Vendor.

## 2.7 DOWNLIGHT FIXTURES AND COMPONENTS

- A. Downlights shall be listed for thru-branch circuit wiring, recessing in ceilings and damp locations. Where installed in plaster or drywall or other inaccessible ceiling types, they shall be UL listed for bottom access.
- B. Provide with tool-less hinged junction box access cover and thermal protection.
- C. Provide telescoping channel bar hangers that adjust vertically and horizontally.

## 2.8 EXIT SIGNS

- A. General requirements: UL 924, NFPA 70, AND NFPA 101. Exit signs shall use no more than 5 watts. Housing shall be made of die-cast aluminum. Provide stencil face and red lettering.

- B. Provide single or double face as scheduled, indicated on plans or as required by the local Authority Having Jurisdiction. Adjust installation position if required for clear visibility, in accordance with applicable codes.
- C. Provide directional arrows (chevrons) as indicated on floor plans and to suit the means of egress or as required by the local Authority Having Jurisdiction.
- D. Where emergency backup battery packs are provided with exit lights, they shall have capacities for continuous operation per applicable codes. Furnish reserve battery capacity to operate remote lamps where indicated.
- E. Complete unit to be furnished in color as selected by the Architect.

## 2.9 LUMINAIRE SUPPORT HANGERS AND COMPONENTS

- A. Wires: ASTM A641/A641M, Class 3, soft temper, galvanized regular coating, 0.1055 inches in diameter (12 gage).
- B. Straps: Galvanized steel, one by 3/16 inch, conforming to ASTM A653/A653M, with a light commercial zinc coating or ASTM A1008/A1008M with an electrodeposited zinc coating conforming to ASTM B633, Type RS.
- C. Rod Hangers: Threaded steel rods, 3/16 inch diameter, zinc or cadmium coated.

## 2.10 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

- A. Structural Characteristics: Comply with AASHTO LTS-4-M.
  - 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
  - 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.3 to obtain the equivalent projected area to be used in pole selection strength analysis.
- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.
- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
  - 1. Materials: Shall not cause galvanic action at contact points.
  - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
  - 3. Anchor-Bolt Template: Plywood or steel.
- D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.
- E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

- F. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

## 2.11 POLES

- A. Provide poles designed for wind loading of 120 miles per hour determined in accordance with AASHTO LTS-5 while supporting luminaires and all other appurtenances indicated. The effective projected areas of luminaires and appurtenances used in calculations shall be specific for the actual products provided on each pole. Poles shall be anchor-base type designed for use with underground supply conductors. Poles shall have oval-shaped handhole having a minimum clear opening of 2.5 by 5 inches. Handhole cover shall be secured by stainless steel captive screws. Metal poles shall have an internal grounding connection accessible from the handhole near the bottom of each pole. Scratched, stained, chipped, or dented poles shall not be installed.

## 2.12 STEEL POLES

- A. Steel Poles: Provide square steel poles having a minimum 11-gage steel with minimum yield/strength of 48,000 psi and hot-dipped galvanized in accordance with ASTM A123/A123M factory finish. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Pole shall be anchor bolt mounted type. Pole shafts shall be one piece. Poles shall be welded construction with no bolts, rivets, or other means of fastening. Joint between shaft and base shall be welded. Pole markings shall be approximately 3 to 4 feet above grade and shall include manufacturer, year of manufacture, top and bottom diameters, and length. Base cover shall be cast 356-T6 aluminum alloy in accordance with ASTM B108/B108M.
- B. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig; one-piece construction up to 40 feet in height with access handhole in pole wall.
  - 1. Shape: Square, straight.
  - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- C. Brackets for Luminaires: Detachable, cantilever, without underbrace.
  - 1. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with stainless steel bolts.
  - 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
  - 3. Match pole material and finish.
- D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- E. Steps: Fixed steel, with nonslip treads, positioned for 15-inch vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet above finished grade.
- F. Intermediate Handhole and Cable Support: Weathertight, 3-by-5-inch handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.

- G. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- H. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- I. Platform for Lamp and Ballast Servicing: Factory fabricated of steel with finish matching that of pole.
- J. Galvanized Finish: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.

## 2.13 ALUMINUM POLES

- A. Aluminum Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall. Provide round aluminum poles manufactured of corrosion resistant aluminum alloys conforming to AASHTO LTS-5 for Alloy 6063-T6 or Alloy 6005-T5 for wrought alloys and Alloy 356-T4 (3, 5) for cast alloys. Poles shall be seamless extruded or spun seamless type with minimum 0.188 inch wall thickness. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Tops of shafts shall be fitted with a round or tapered cover. Base shall be anchor bolt mounted, made of cast 356-T6 aluminum alloy in accordance with ASTM B108/B108M and shall be machined to receive the lower end of shaft. Joint between shaft and base shall be welded. Base cover shall be cast 356-T6 aluminum alloy in accordance with ASTM B108/B108M. Hardware, except anchor bolts, shall be either 2024-T4 anodized aluminum alloy or stainless steel. Manufacturer's standard provision shall be made for protecting the finish during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape and shipping small parts in boxes.
- B. Poles: Poles: ASTM B 209 (ASTM B 209M), 5052-H34 marine sheet alloy with access handhole in pole wall.
  - 1. Shape: Round, straight
  - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- D. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
  - 1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.

2. Finish: Same as luminaire.

#### 2.14 BRACKETS AND SUPPORTS

- A. ANSI C136.3, ANSI C136.13, and ANSI C136.21, as applicable. Pole brackets shall be not less than 1-1/4 inch secured to pole. Slip-fitter or pipe-threaded brackets may be used, but brackets shall be coordinated to luminaires provided, and brackets for use with one type of luminaire shall be identical. Brackets for pole-mounted street lights shall correctly position luminaire no lower than mounting height indicated. Mount brackets not less than 24 feet above street. Special mountings or brackets shall be as indicated and shall be of metal which will not promote galvanic reaction with luminaire head.

#### 2.15 DECORATIVE POLES

- A. Pole Material:
  1. Cast ductile iron.
  2. Cast gray iron, according to ASTM A 48/A 48M, Class 30.
  3. Cast aluminum.
- B. Mounting Provisions: Bolted to concrete foundation.

#### 2.16 POLE FOUNDATIONS

- A. Anchor bolts shall be steel rod having minimum yield strength of 50,000 psi and shall be galvanized in accordance with ASTM A153/A153M. Concrete shall be as specified in Division 03 Specification Section, CAST-IN-PLACE CONCRETE.

#### 2.17 FUSING: All luminaires shall be fused. Fuse pole mounted fixtures at handhole.

#### 2.18 POLE ACCESSORIES

- A. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Division 26 Section "Wiring Devices" for ground-fault circuit-interrupter type.
  1. Recessed, 12 inches above finished grade.
  2. Nonmetallic polycarbonate plastic or reinforced fiberglass, weatherproof in use, cover, color to match pole, that when mounted results in NEMA 250, Type 4X enclosure.
  3. With cord opening.
  4. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.

#### 2.19 EQUIPMENT IDENTIFICATION

- A. Manufacturer's Nameplate: Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.
- B. Factory-Applied Labels: Provide labeled luminaires in accordance with UL 1598 requirements. All light fixtures shall be clearly marked for operation of specific LED's and drivers according to proper type. The following characteristics shall be noted in the format "Use Only \_\_\_\_\_":

1. LED or lamp type, and nominal wattage
  2. Driver or ballast type
  3. Correlated color temperature (CCT) and color rendering index (CRI)
  4. All markings related to lamp type shall be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place. Drivers and ballasts shall have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.
- 2.20 FACTORY APPLIED FINISH: Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

### **PART 3 - EXECUTION:**

#### **3.1 INSTALLATION**

- A. Architect's reflected ceiling plan (RCP) shows actual locations of all light fixtures, diffusers and system devices. Report to the Architect/Engineer any conflicts. Do not scale plans for exact location of lighting fixtures.
- B. Install luminaires in accordance with luminaire manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation", and NEMA standards.
- C. Electrical installations shall conform to and meet IEEE C2, NFPA 70, and to the requirements specified herein.
- D. Installed luminaires shall be provided with protective covering by Contractor until such time as the space(s) is cleaned and ready for occupancy.
- E. Align, mount and level the luminaires uniformly. All luminaires shall be installed plumb/true and level as viewed from all directions. Luminaires shall remain plumb and true without continual adjustment.
- F. The Contractor shall coordinate the lighting system installation with the relevant trades so as to eliminate interferences with hangers, mechanical ducts, sprinklers, pipes, steel, etc. Avoid interference with and provide clearance for equipment.
- G. Set luminaires plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturers' directions and approved drawings. Mounting heights specified or indicated shall be to the bottom of fixture for ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures. Obtain approval of the exact mounting for lighting fixtures on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed.
- H. Recessed, semi-recessed and surface fixtures shall be independently supported from the buildings structure by a minimum of four wires per fixture and located near each corner of each fixture. Ceiling grid clips are not allowed as an alternative to independently supported light fixtures. Round fixtures or fixtures smaller in size than the ceiling grid shall be independently supported from the building structure by a minimum of four wires per fixture spaced approximately equidistant around the fixture. Do not support fixtures by ceiling acoustical panels. Where fixtures of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support such

fixtures independently and provide at least two 3/4 inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the fixture. Provide wires for lighting fixture support in this section. Lighting fixtures installed in suspended ceilings shall also comply with the requirements of Division 09 Specification Sections GYPSUM BOARD, ACOUSTICAL PANEL CEILINGS and SUSPENDED DECORATIVE WOOD GRIDS. Support lay-in ceiling light fixtures as follows:

1. Support fixtures with four (4) wires, with one (1) at each corner. Hanger wires shall be installed within 15 degrees of plumb or additional support shall be provided. Wires shall be attached to fixture body and to the building structure (not to the supports of other work or equipment).
  2. Where building structure is located such that 15 degrees cannot be maintained, the Contractor shall provide "Uni-strut" or similar structure to meet this requirement.
  3. Support Clips: All fixtures shall be furnished with hold down clips to meet applicable seismic codes. Provide four (4) clips per fixture minimum or the equivalent thereof in the installation trim. Fasten to light fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application. Contractor shall install clips per manufacturer's requirements. If screws are required, they shall be provided.
- I. Lighting Fixture Supports:
1. Shall provide support for all of the fixtures.
  2. Shall maintain the fixture positions after cleaning and relamping.
  3. Shall support the luminaires without causing the ceiling or partition to deflect
  4. For installation in suspended ceilings, ensure that the luminaires are supported such that there is no resultant bowing or deflection of the ceiling system.
- J. Downlights, exit signs and battery pack supported by or attached to ceiling grid or tile shall be provided with one hanger wire at each end. Provide a minimum of two, located at opposite corners. Hanger wires shall be installed within 15° of plumb, maximum or additional support shall be provided. Wires shall be attached to the fixture body and to the building structure and not to the supports of other work or equipment.
- K. Luminaires installed and used for working light during construction shall be replaced prior to turnover to the Owner if more than 3 percent of their rated life has been used. Fixtures shall be tested for proper operation prior to turn-over and shall be replaced if necessary, with new lamps from the original manufacturer.
- L. All fluorescent lamps shall be seasoned for a minimum of 12 hours and a maximum of 100 hours in full-on mode without dimming prior any dimming and prior to turn-over to Owner. All lamps used for convenience lighting during construction for periods collective operation longer than 100 hours and any lamps which have failed/burned-out shall be replaced with identical new lamps, which shall then be seasoned as described above, immediately prior to the date of substantial completion as determined by the Architect.
- M. Suspended fixtures shall hang plumb and shall be located with no obstructions within the 45 degree range in all directions. The stem, cable, canopy and fixture shall be capable of 45 degree swing. Suspended fixtures in continuous rows shall have internal wireway systems for end to end wiring and shall be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Aligning

splines shall be used on extruded aluminum fixtures to assure hairline joints. Steel fixtures shall be supported to prevent "oil-canning" effects. Fixture finishes shall be free of scratches, nicks, dents, and warps, and shall match the color and gloss specified. Pendants shall be finished to match fixtures. Aircraft cable shall be stainless steel. Canopies shall be finished to match the ceiling and shall be low profile unless otherwise shown.

- N. Whenever a luminaire or its hanger canopy is installed directly to a surface mounted junction box, a finishing ring painted to match the ceiling, shall be used to conceal the junction box.
- O. Rigidly align continuous rows of light fixtures for true in-line appearance.
- P. Exit Signs and Emergency Lighting Units: Wire exit signs ahead of the switch to the un-switched emergency lighting life-safety branch circuit located in the same room or area.
- Q. Light fixture whips shall be supported from the building structure. Do not clip to lay-in ceiling support wires.
- R. Exterior Fixtures:
  - 1. Exterior building mounted light fixtures shall not be installed until after the building exterior has been rinsed clean of any corrosive cleaning materials. Damaged fixtures shall be replaced by the Contractor at no cost.
  - 2. Provide exterior rated waterproof junction boxes for all fixtures and splices.
  - 3. Utilize weatherproof silicone filled wire nuts and seal all junction boxes and conduit with potting compound to create waterproof barriers. Inspect all splices and fixtures for continuity prior to potting.
  - 4. Lubricate all threaded parts with a high temperature waterproof anti-seize lubricant, including lamp bases and sockets, to prevent seizing and corrosion.
  - 5. All low-voltage wiring to be UV resistant, UL approved for use without conduit, stranded low-voltage wire (Q-Wire by Q-Tran or equal) for use in outdoor and underground applications, gauge as appropriate to avoid voltage drop.
- S. Track Lighting: The Electrical Contractor shall allow for all track lighting to be wired with individual home runs (not looped) so invisible feeds (no junction box at end of track) may be utilized.
- T. Transformers (applies to all transformers including (but not limited to) low voltage, neon, remote ballast, LED power supplies, exterior locations):
  - 1. Electrical Contractor to locate all transformers (including low voltage, neon, remote ballasts, led power supplies, etc.) near fixtures in a well-ventilated and accessible location. Transformers must be installed (per codes) in accessible areas large enough to dissipate the heat of the transformer. Temperatures should not exceed 100°F (38°C).
  - 2. Transformers should be mounted as close to the load/feed lamp holders as practical to keep the secondary feeds as short as possible.
  - 3. Electrical Contractor to determine wire size according to load and wire length to eliminate voltage drop. If voltage drop is a problem after installation, the Electrical Contractor is responsible for reinstallation (at no additional cost) of transformer and wire to solve problem.

4. Electrical Contractor to label front of transformer with load name and load location. For example: "Large Display Case @ Entry to Main Dining Room."
- U. Light fixture locations in mechanical and electrical equipment rooms/areas, as indicated on floor plans, are approximate. Locate light fixtures to avoid equipment, ductwork, and piping. Locate around and between equipment to maximize the available light. Coordinate mounting heights and locations of light fixtures to clear equipment. Request a meeting with the Engineer if uncertain about an installation. All suspended light fixtures shall be mounted square and plumb.
- V. Contractor shall be responsible for sealing all luminaires for wet locations (i.e. all knock-outs, all pipe and wire entrances, etc.) to prevent water wicking.
- W. Coordinate between the electrical and ceiling trades to ascertain that approved luminaires are furnished in the proper sizes, with the proper flange details, and installed with the proper devices (hangers, clips, trim frames, flanges), to match the ceiling system being installed.
- X. All reflecting surfaces, glass or plastic lenses, ballast housings, parabolic louvers, downlighting alzak cones and specular reflectors and other decorative elements shall be installed after completion of ceiling tile installation, plastering, painting and general cleanup.
- Y. Handle all reflecting surfaces, glass or plastic lenses, ballast housings, parabolic louvers, downlighting alzak cones and specular reflectors and other decorative elements with care during installation or lamping to avoid fingerprints or dirt deposits.
- Z. It is preferred that louvers be shipped and installed with clear plastic bags to protect louvers. At close of project, and after construction air filters are changed, remove bags.

### 3.2 POLE INSTALLATION

- A. Poles: Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end. Provide ornamental covers to match pole and galvanized nuts and washers for anchor bolts. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit ell. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location. Install according to pole manufacturer's instructions. Alterations to poles after fabrication will void manufacturer's warranty and shall not be allowed
- B. Excavation: Restrict excavation in size to that which will provide sufficient working space for installation of concrete forms. Should soil conditions at the bottom of the excavation be unsuitable as a foundation, as determined by the Architect, take the excavation down to firm soil and fill to required grade with concrete or satisfactory soil materials as directed. Perform excavations in a manner to prevent surface, subsurface, and ground water from flowing into the excavation. Use pumps or other dewatering methods necessary to convey the water away from the excavation work below ground-water level.
- C. Formwork: Construct forms of wood, plywood, steel, or other acceptable materials fabricated to conform to the configuration, line, and grade required. Reinforce formwork

to prevent deformation while concrete is being placed and consolidated. Wet or coat formwork with a parting agent before placing concrete.

- D. Concrete Pole Foundations: Set anchor bolts with exposed threaded ends vertically positioned in the concrete using a template supplied by pole manufacturer in accordance with the lighting standard manufacturer's recommendations. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- E. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- F. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:
  - 1. Fire Hydrants and Storm Drainage Piping: 60 inches
  - 2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet
  - 3. Trees: 15 feet from tree trunk.
- G. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
  - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
  - 2. Grout void between pole base and foundation. Use non-shrink or expanding concrete grout firmly packed to fill space.
  - 3. Install base covers unless otherwise indicated.
  - 4. Use a short piece of 1/2-inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- H. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
  - 1. Dig holes large enough to permit use of tampers in the full depth of hole.
  - 2. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.
- I. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
  - 1. Make holes 6 inches in diameter larger than pole diameter.
  - 2. Fill augured hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi at 28 days, and finish in a dome above finished grade.
  - 3. Use a short piece of 1/2-inch diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
  - 4. Cure concrete a minimum of 72 hours before performing work on pole.
- J. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch below top of concrete slab.
- K. Raise and set poles using web fabric slings (not chain or cable).

### 3.3 BOLLARD LUMINAIRE INSTALLATION

- A. Align units for optimum directional alignment of light distribution.
- B. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

### 3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

- A. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

### 3.5 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

### 3.6 GROUNDING

- A. Bond luminaires and metal accessories to the grounding system per National Electrical Code.
- B. Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.
- C. At each pole and light bollard, provide a driven ground rod into the earth so that after the installation is complete, the top of the ground rod will be approximately 1 foot below finished grade.
- D. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
  - 1. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
  - 2. Install grounding electrode for each pole.
- E. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
  - 1. Install grounding electrode for each pole.
  - 2. Install grounding conductor and conductor protector.
  - 3. Ground metallic components of pole accessories and foundations.

### 3.7 IDENTIFICATION

- A. Light fixtures served from multiple power sources, such as emergency fixtures fed from emergency transfer relay, shall have the following label affixed to it: "DANGER - ELECTRICAL SHOCK HAZARD - LIGHT FIXTURE HAS MULTIPLE POWER SOURCES"

### 3.8 CLEANING

- A. At completion of each phase and the time of final acceptance by the Owner, all lighting fixtures shall have been thoroughly cleaned with materials and methods recommended by the manufacturer.
- B. Any lens, louver or cone showing dirt or fingerprints shall be cleaned with solvent recommended by the manufacturer to a like-new condition or replaced as necessary in order to turn over to the Owner new fixtures at beneficial occupancy.
- C. All fingerprints, dirt, tar, smudges, drywall mud and dust, etc. shall be removed by the Contractor from the luminaire bodies, reflectors, trims, and lens/louvers prior to final acceptance. All reflectors shall be free of paint other than factory-applied, if any.

### 3.9 TESTING AND ADJUSTMENT

- A. The lighting and lighting controls systems shall be synchronized and fully operable to address the lighting operation in a complete and code-compliant manner.
- B. All adjustable luminaires shall be aimed, focused, locked, etc., by the Contractor under the observation of the Architect and Engineer. As aiming and adjusting is completed, locking setscrews and bolts and nuts shall be tightened securely by the Contractor.
- C. Contractor shall coordinate with Architect to establish the number of two-member crews required for aiming and adjusting. All aiming and adjusting shall be performed after the entire installation is complete for each phase or area. The Contractor shall be responsible for notifying the Architect of appropriate time for final luminaire adjustment.
- D. All ladders, scaffolds, lifts, gloves, cleaning cloths, access/adjustment tools, etc. required for aiming and adjusting luminaires shall be furnished by the Contractor.
- E. Where possible, units shall be focused during the normal working day. However, where daylight interferes with seeing lighting effects, aiming shall be accomplished at night at no premium cost.

### 3.10 OPERATION AND MAINTENANCE DATA

- A. Submit operation and maintenance data in accordance with Division 01 Specification Section SUBMITTALS and OPERATION AND MAINTENANCE, IECC and as specified herein, showing all light fixtures, control devices and all interconnecting control wire, conduit and associated hardware.
- B. Contractor shall be responsible for obtaining from his supplying light fixture manufacturers, for each type of light fixture, a recommended maintenance manual including, tools required, types of cleaners to be used and replacement parts identification list.
- C. Provide at least three (3) CDs/DVDs with high resolution PDF files of all equipment product data for Owner's use in equipment identification and maintenance with recommended maintenance manuals including, at a minimum:
  - 1. Vendor and local representative's contact information
  - 2. Tools required
  - 3. Types of cleaners to be used
  - 4. Replacement parts identification lists
  - 5. Equipment product data (high-quality reproducible copies)
  - 6. Warranty documentation

### 3.11 FIELD QUALITY CONTROL:

- A. Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test to show that equipment operates in accordance with requirements of this section.
- B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal and emergency power sources.
- C. Dimming Drivers. Test for full range of dimming capability. Observe for visually detectable flicker over full dimming range.
- D. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
- E. Inspect each light fixture for damage. Replace damaged light fixtures at no cost to the Owner.
- F. Fixtures showing dirt, dust or fingerprints shall be restored to like new condition or shall be replaced at no cost.
- G. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.
- H. Illumination Tests:
  - 1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):
    - a. IESNA LM-5, "Photometric Measurements of Area and Sports Lighting Installations."
    - b. IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
    - c. IESNA LM-52, "Photometric Measurements of Roadway Sign Installations."
    - d. IESNA LM-64, "Photometric Measurements of Parking Areas."
    - e. IESNA LM-72, "Directional Positioning of Photometric Data."

### 3.12 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two (2) visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
  - 1. Adjust aimable luminaires in the presence of Architect.

## END OF SECTION

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## **SECTION 27 00 00**

### **GENERAL REQUIREMENTS FOR COMMUNICATIONS**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED REQUIREMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 01 and 26 Specification Sections, apply to this Section.

##### **1.2 SUMMARY**

- A. Division 27 – Communications governs the structured cabling infrastructure for the low-voltage information transport systems, which include but are not limited to voice, data, and their pathways.
- B. The installed structured cabling infrastructure should be able to support interconnections to active telecommunications equipment for IP telephony, desktop computers, IP surveillance cameras, and other technologies in a multi-vendor, multi-product environment. The structured cabling infrastructure shall adhere to applicable standards as listed below with respect to performance, pathways, distribution, administration, and grounding of the system. The structured cabling system shall be installed in accordance with local codes and regulations.
- C. Contractor shall be solely responsible for all parts, labor, testing, documentation and all other processes and physical apparatus necessary to turn over the completed cabling system and associated infrastructure fully warranted and operational for acceptance by Owner.
- D. This specification includes structured cabling design considerations, product specifications, and installation and testing requirements for low-voltage network systems and associated infrastructure including, but not limited to:
  - 1. Horizontal Cabling and Terminations
  - 2. Backbone Cabling and Terminations
  - 3. Telecommunications Pathways
  - 4. Communications Equipment Room Fittings
  - 5. Communications Grounding and Bonding Systems
  - 6. Cable Labeling and Administration
- E. The following equipment is to be owner-furnished, owner-installed. This does not alleviate the contractor from fully coordinating with the owner to ensure compatibility of the contractor's systems with the owner's systems and equipment:
  - 1. Telephones
  - 2. Client Workstations, PCs, monitors, printers, faxes

3. Wireless Access Points
4. Network Switches
5. Patch cables and Equipment cords for owner furnished equipment

### 1.3 REFERENCES

- A. Contractor is responsible for knowledge and application of current versions of all applicable standards and codes. In cases where listed standards and codes have been updated, Contractor shall adhere to the most recent revisions, including all relevant changes or addenda at the time of installation.
- B. This document does not replace any code, either partially or wholly. The contractor shall conform to local codes and regulations that apply to this project
- C. If there is a conflict between applicable documents, then the more stringent requirement shall apply.
- D. Reference Standards
  1. NFPA
    - a. NFPA 70, National Electric Code (NEC)
  2. Telecommunications Industry Association (TIA):
    - a. ANSI/TIA-568.0-D, "Generic Telecommunications Cabling for Customer Premises"
    - b. ANSI/TIA-568.1-D, "Commercial Building Telecommunications Cabling Standards - Part 1 General Requirements"
    - c. ANSI/TIA-568.2-D, "Balanced Twisted Pair Telecommunications Cabling and Components"
    - d. ANSI/TIA-568.3-D, "Optical Fiber Cabling Components"
    - e. ANSI/TIA-569-D, "Commercial Building Standard for Telecommunications Pathways and Spaces"
    - f. ANSI/TIA/EIA-598-C, "Optical Fiber Cable Color Coding"
    - g. ANSI/TIA-606-C, "Administration Standard for Telecommunications Infrastructure"
    - h. ANSI-TIA-607-C, "Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises"
    - i. ANSI/TIA-758-C, "Customer-Owned Outside Plant Telecommunications Infrastructure Standard"
    - j. ANSI/TIA-1152-A, "Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling"
  3. BICSI
    - a. BICSI TDMM "Telecommunications Distribution Design Manual"
    - b. BICSI ITSIM "Information Technology Systems Installation Manual"
    - c. NECA/BICSI 568 "Standard for Installing Commercial Building Telecommunications Cabling"
    - d. NECA/BICSI 607 "Standard for Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings"
  1. NECA
    - a. NECA 1, "Standard for Good Workmanship in Electrical Construction"

2. IEEE
  - a. C2, National Electrical Safety Code

#### 1.4 ADMINISTRATIVE REQUIREMENTS

##### A. Coordination:

1. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance configuration with Owner.
2. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.
3. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

##### B. Pre-installation Meetings

1. Organize pre-installation meeting with telecommunications and LAN equipment suppliers, Engineer and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
2. Record agreements reached in meetings and distribute them to project team.
3. Adjust arrangements and locations of racks, sleeves, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of utility demarcation, and telecommunications and LAN equipment.
4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.

#### 1.5 ACTION SUBMITTALS

- A. Prior to the start of work the contractor shall submit the following. Work shall not proceed without the Engineer's and Owner's approval of the submitted items.

##### B. Product Data: For each type of product specified.

1. Include manufacturer's data sheets indicating construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment and components.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Format and Organization: Electronic PDF submittal organized in the following order
  - a. Cover: clearly display the following information: Owner name, Project name, Submittal name, project submittal number, Contractor name and contact information, applicable specification section numbers.

- b. Table of Contents: Include a TOC that lists materials by section number, with a brief product description, manufacturer and part number, and list the submittal page number per product
  - c. Product Information
- 4. Clearly and precisely indicate the submitted product and accessories by part number using an electronic annotation (arrow, rectangle, oval, etc.).
- C. Equipment Shop Drawings: For custom enclosures, cabinets, manholes, signal reference grid, etc. Include plans, elevations, sections, and attachment details.
  - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - 2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
- D. System Labeling Schedules with proposed designations for cables, outlets, terminations, and equipment.
- E. Coordination Drawings: drawings reviewed and stamped by RCDD with floor plans, sections, riser diagrams, and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:
  - a. Telecommunications room plans and rack elevations.
  - b. Telecommunications cable tray and pathway layout with relationships to other building elements.
  - c. Telecommunications system access points.
  - d. Telecommunications grounding system.
  - e. Cross Connects
  - f. Patch Panels
  - g. Telecommunications conductor drop locations.
  - h. Typical telecommunications details.
  - i. Mechanical, electrical, and plumbing systems.
  - j. Firestopping

#### 1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data for Manufacturer, Contractor, Project RCDD, Project Manager, Lead Technician, and Installers.
- B. Sample Warranties
- C. Sample Field Quality Control Reports
- D. Twisted pair and Optical Fiber Cable Testing Plans:
  - 1. Sample test report sheet for each type of test required
  - 2. Description of the cable testing procedures to be used including equipment to be used and testing standards equipment will test to.

## 1.7 CLOSEOUT SUBMITTALS

- A. As-Built Drawings: Plans showing as-built locations that fully represent actual installed conditions and that incorporate modifications made during the course of construction.
- B. Operation and Maintenance Data:
  - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data" and Section 260500 "General Provisions – Electrical" include the following:
    - a. Results of the ground-resistance and bonding resistance tests.
    - b. Cable test results.
    - c. Manufacturer's recommended maintenance
- C. Product and System Warranty Documentation from both manufacturer and contractor.
- D. Labeling and Administrative printouts and digital copies on USB media.
  - 1. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables served from that particular room along with their designations, origins, and destinations. Protect with rigid frame and clear plastic cover.
  - 2. Cabling Administration Drawings: Install in a prominent location in each equipment room and wiring closet. Show building floor plans that identify the location and labelling of Communications devices served out of each telecom room. Protect with rigid frame and clear plastic cover. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, backbone and horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- E. Final test result printouts and backup on USB media.

## 1.8 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories shall be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Manufacturer Qualifications
  - 1. Five continuous years, minimum, design and manufacture of the materials and equipment specified herein.
  - 2. Manufacturer(s) of products and equipment specified herein shall demonstrate that they have a quality assurance program in place to assure that the specifications are met. Including at a minimum:
    - a. Incoming inspection of raw materials
    - b. In-process inspection and final inspection of the cable product
    - c. Calibration procedures of test equipment to be used in the qualifications of the product

- d. Recall procedures in the event that out of calibration equipment is identified.
  3. Conform to government standards on quality assurance for applications within these specifications.
- C. Contractor Qualifications: Provide documentation of the following qualifications:
1. Be in business a minimum of 5 continuous years
  2. Contractor shall demonstrate satisfaction of sound financial condition and can be adequately bonded and insured.
  3. Possess those licenses/permits required to perform telecommunications installations in the specified jurisdiction.
  4. Personnel knowledgeable in local, state, province and national codes, and regulations. All work shall comply with the latest revision of the codes or regulations. When conflict exists between local or national codes or regulations, the most stringent codes or regulations shall be followed.
  5. Must possess current liability insurance certificates.
  6. Contractor must be registered with BICSI and have at least one RCDD on staff. At least one RCDD shall be responsible for the implementation of the project.
  7. Must have personnel fluent in the use of Computer Aided Design and possess and operate CAD software using .DWG format.
  8. The Contractor shall be a certified installer in good standing with the approved manufacturer.
- D. Contractor Training: Provide documentation of the following qualifications:
1. Personnel trained and certified in the design and installation of the approved manufacturer's products.
  2. Personnel trained and certified in fiber optic cabling, fusion splicing, termination and testing techniques. Personnel must have successfully attended an appropriate training program, which includes testing with an OLTS and OTDR, and have obtained a certificate as proof thereof.
  3. Personnel trained in the installation of pathways and support for housing horizontal and backbone cabling.
- E. Project Personnel Requirements: Contractor must have the following personnel certified by BICSI on staff and assigned to the project.
1. Project RCDD: Preparation of Shop Drawings, cabling administration Drawings, and field-testing program development by an RCDD who shall be a full-time employee of the installing contractor, shall be familiar with the project, and conduct weekly inspections.
  2. Project Manager: Minimum BICSI certified Registered Telecommunications Project Manager (RTPM) who shall attend all project meetings and oversee/coordinate all work at the project site.
  3. Lead Technician: Minimum BICSI certified Technician who shall provide direct supervision of Installers and be present at all times when work of this Section is performed at the project site.

4. Installers: Personnel installing any part of the structured cabling system shall be a minimum BICSI certified Level 1 Installer or shall have equivalent training and certification from the approved manufacturer.
- F. References: The Customer may, with full cooperation of The Contractor, visit client installations to observe equipment operations and consult with references. Specified visits and discussion shall be arranged through The Contractor; however, The Contractor personnel shall not be present during discussions with references. The Contractor must provide a minimum of three (3) reference accounts at which similar work, both in scope and design, have been completed by The Contractor within the last two (2) years.

#### 1.9 DELIVERY, STORAGE, AND HANDLING

- A. Environmental Limitations: Do not deliver or install equipment, cables, and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
- B. Visually inspect cables upon receipt at Project site. If damage is suspected, test cables to verify and validate the manufacturer's factory testing certifications.
  1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
  2. Test each pair of UTP cable for open and short circuits.
- C. Comply with manufacturer's storage and handling requirements for each product.
- D. Maintain factory wrapping or provide a heavy canvas/plastic cover to protect units from dirt, water, construction debris, and traffic.
- E. Do not install damaged materials and equipment.
- F. Visibly damaged products shall be returned to the supplier and replaced at no additional cost to the Owner.

#### 1.10 GENERAL PRODUCT WARRANTY

- A. General Requirements: Comply with additional requirements in contract general requirements and extended warranties required in other specification sections. Refer to all other Division 27 sections for specific additional warranty requirements that exceed or are in addition to those of this section.
- B. Contractor shall provide all services, materials, and equipment necessary for successful operation of entire telecommunications system including but not limited to structured cabling system, pathways, grounding and bonding system, and firestopping for a period of one year after system acceptance. Scope of warranty includes all equipment, devices, wiring, accessories, software, hardware, installation,

programming, and configuration required to maintain a complete and operable system. Provide manufacturer's published recommended preventative maintenance procedures during warranty period. This shall apply to all items except those specifically excluded, or items wherein a longer period of service and warranty is specified or indicated. All warranties shall be effective for one year, minimum, from date Certificate of Final Acceptance is issued. Use of systems provided under this section for temporary services and facilities shall not constitute final acceptance of work nor beneficial use by Owner and shall not institute warranty period. The warranty shall cover repair or replacement of defective materials, equipment, workmanship, and installation that may be incurred during this period. Warranty work is to be done promptly and to Owner's satisfaction. In addition, warranty shall cover correction of damage caused in making necessary repairs and replacements under warranty. Additional warranty responsibilities are:

1. Obtain written equipment and material warranties offered in manufacturer's published data without exclusion or limitation, in Owner's designated name. Replace material and equipment that require excessive service during guarantee period as determined by Owner.
2. Provide 2-business day service beginning on date of Substantial Completion and lasting until termination of warranty period. Service shall be at no cost to Owner. Service can be provided by installing contractor or by a separate service organization. Choice of service organization shall be subject to Owner's approval. Submit name and a phone number that will be answered on a 24-hour basis each day of week, for duration of service.
3. Submit copies of equipment and material warranties to Owner before final acceptance.
4. At end of warranty period, transfer manufacturers' equipment and material warranties still in force to Owner, at no additional costs to the Owner.
5. If warranty work problems cannot be corrected immediately to Owner's satisfaction, advise Owner in writing, describing efforts to correct situation, and provide analysis of cause for problem. If necessary, to resolve problem, provide at no cost services of manufacturer's engineering and technical staff at site in a timely manner to analyze warranty issues, and develop recommendations for correction, for review and approval by Owner.

#### 1.11 ADVANCED SYSTEM WARRANTY

- A. The structured cabling system shall be covered by a two-part system performance and extended product warranty guaranteed for a minimum of [25 years]. The advanced system warranty shall ensure installation and system performance for the duration of the warranty period.
- B. The first part is an assurance program, which guarantees the end-to-end link transmission performance conforms to the applicable performance standards specified herein and will support the applications for which it is designed for the duration of the warranty period.
- C. The second portion of the certification is an extended product warranty provided by the manufacturer and the contractor on all structured cabling products within the system

(cords, telecommunications outlet/connectors, cables, cross-connects, patch panels, fiber panels, etc.).

- D. The contractor shall have the sole responsibility for following the manufacturer's conditions and terms for the installation to qualify for the advanced system warranty. Requirements may include but are not limited to:
  - 1. Layout and Installation by a manufacturer approved installer with BICSI certification.
  - 2. Submission of warranty pre-approval, final application, test reports, and bill of materials in a timely manner.
  - 3. Certification testing of all links to appropriate standard.
  - 4. Use of manufacturer approved and calibrated test equipment.
  - 5. Coordination of pre-construction conference.
  - 6. Coordination of Manufacturer Pre/Post Installation Inspection.

## **PART 2 - PRODUCTS:**

### **2.1 GENERAL**

- A. Materials used shall present no environmental or toxicological hazards as defined by current industry standards and shall comply with OSHA and EPA standards, other applicable federal, state, and local laws.
- B. Product numbers are subject to change by the manufacturer without notification. In the event a product number is invalid or conflicts with the written description, notify the Engineer in writing prior to ordering the material and performing installation work.

### **2.2 SUBSTITUTIONS**

- A. Conform to the substitutions requirements and procedures outlined in Division 01.
- B. Only one substitution for each product specified will be considered and substitutions must be submitted to Engineer a minimum of 10 days prior to bid using the standard CSI substitution request form.
- C. Where products are noted as "or equal", a product of equivalent design, manufacture, and performance will be considered. Submit product data (product information, catalog cuts, pertinent test data, etc.) to substantiate that the product is in fact equivalent to that specified. The burden of proof that the substituted product is equivalent to the specified product rests with the Contractor. Whenever material, process or equipment is specified in accordance with an industry specification (ANSI, TIA, etc), UL rating, or other association standard, present an affidavit from the manufacturer certifying that the product complies with the particular standard specification. When requested by the Engineer, submit supporting test data to substantiate compliance.
- D. Manufacturers' names and model numbers used in conjunction with materials, processes or equipment included in the contract documents are used to establish

standards of quality, utility and appearance. Materials, processes or equipment that, in the opinion of the Engineer, are equivalent in quality, utility and appearance will be approved as substitutions to that specified when "or equal" follows the manufacturers' names or model number(s).

- E. When the Engineer accepts a substitution in writing, it is with the understanding that the Contractor guarantees the substituted product, component, article, or material to be equivalent to the one specified and dimensioned to fit within the construction according to contract documents. Do not provide substituted material, processes, or equipment without written authorization from the Engineer. Assumptions on the acceptability of a proposed substitution, prior to acceptance by the Engineer, are at the sole risk of the Contractor.
- F. Approved substitutions shall not relieve the Contractor of responsibilities for the proper execution of the work, or from provisions of the specifications.
- G. Contractor shall pay expenses, without additional charge to the Owner, in connection with substitution materials, processes and equipment, including the effect of substitution on self, subcontractor's or other Contractor's work.
- H. Contractor shall be responsible and assume all costs for removal and replacement of any substituted product installed without prior written approval. Such costs shall include, but not be limited to labor, materials as well as any penalties, fees or costs incurred for late completion.

### **PART 3 - EXECUTION:**

#### **3.1 EXAMINATION**

- A. Verify existing conditions, stated under other sections, are acceptable for installation in accordance with manufacturer's instructions.

#### **3.2 DEMOLITION**

- A. In addition to demolition requirements in Division 01 and 26, the contractor shall disconnect and remove abandoned existing communications components back to their source. This includes sources that are outside of the boundaries of the project area.
- B. Any abandoned cabling deemed unfeasible to remove by the Engineer shall be tagged and labeled at both ends as Abandoned.
- C. The owner shall have first right of refusal for any components of the telecommunications system removed during demolition.

### 3.3 INSTALLATION

- A. Comply with NECA 1
- B. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications' equipment and other nearby installations. Connect in such a way as to facilitate future maintenance with minimum interference from other items in the vicinity.
- C. Under no condition shall the Contractor install any equipment or component that will void Manufacturer warranty or create such conditions that will reduce equipment performance, longevity, and life.

### 3.4 FIELD QUALITY CONTROL

- A. Tests
  - 1. Conduct tests of equipment and systems to demonstrate compliance with requirements specified. Reference individual Specification Sections for required tests. Document tests and include in Operation and Maintenance Manuals.

### 3.5 CLEANING

- A. In addition to cleaning requirements in Division 01 and 26, thoroughly clean exposed portions of equipment upon completion of installation. Remove temporary labels and traces of foreign substances. Remove construction debris and surplus materials accumulated during work.
- B. Leave finished work and adjacent surfaces in neat, clean condition with no evidence of damage.
- C. Repair or replace damaged installed products.

### 3.6 SYSTEM ACCEPTANCE

- A. System cannot be considered for acceptance until work is completed and demonstrated to Engineer that installation is in strict compliance with Specifications, Drawings and manufacturer's installation instructions, particularly in reference to following:
  - 1. Testing Reports
  - 2. Cleaning
  - 3. Operation and Maintenance Manuals
  - 4. Training of Operating Personnel
  - 5. Record Drawings
  - 6. Warranty Certificates, including extended manufacturer's warranties.

**END OF SECTION**

## **SECTION 27 05 26**

### **GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" and as noted below.

##### **1.2 SUMMARY**

- A. Description: The telecommunications bonding and grounding system and its interconnections to the electrical system provide an electrically continuous, low impedance path for all connected telecommunications equipment and pathways.
- B. Section Includes:
  - 1. Bonding conductors.
  - 2. Bonding connectors.
  - 3. Bonding busbars.

##### **1.3 DEFINITIONS**

- A. TBC: Telecommunications Bonding Conductor.
- B. SBB: Secondary Bonding Busbar.
- C. PBB: Primary Bonding Busbar.
- D. RBB: Rack Bonding Busbar
- E. TBB: Telecommunications Bonding Backbone
- F. BBC: Backbone Bonding Conductor
- G. TEBC: Telecommunications Equipment Bonding Conductor
- H. RBC: Rack Bonding Conductor
- I. Service Provider: The operator of a service that provides telecommunications transmission delivered over access provider facilities.

#### 1.4 SUBMITTALS

- A. Comply with Section 270000 "General Requirements for Communications"

### **PART 2 - PRODUCTS:**

#### 2.1 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.
- C. Comply with TIA-607-C.

#### 2.2 CONDUCTORS

- A. Comply with UL 486A-486B.
- B. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.
  - 1. Ground wire for custom-length equipment ground jumpers shall be minimum No. 6 AWG, 19-strand, UL-listed, Type THHN wire.

#### 2.3 CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products from one of the following or approved equal:
  - 1. Burndy
  - 2. Harger Lightning and Grounding
  - 3. Panduit Corp.
  - 4. Erico
  - 5. Chatsworth CPI
  - 6. Thomas & Betts
  - 7. Eaton
- B. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.
- C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.

1. Electroplated tinned copper, C and H shaped.
- D. Busbar Connectors: Cast silicon bronze, solderless irreversible compression type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch centers for a two-bolt connection to the busbar.
- E. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- F. Bolted connectors: copper or copper alloy, bolted pressure-type, with at least two bolts.

## 2.4 BONDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, provide products from one of the following:
  1. Ortronics
- B. General Requirements:
  1. Predrilled BICSI/TIA-607 style hole pattern for use with lugs specified in this Section.
  2. Mounting Hardware: Stand-off brackets that provide at least a **4-inch** clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
  3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
  4. Busbar length shall be sized to accommodate initial conductors plus a 50% growth factor.
- C. Primary Bonding Busbar (PBB): Predrilled, wall-mounted, rectangular bars of electro-tin plated copper, **1/4 by 4 inches** in cross section, minimum 18 inches in length or as indicated on Drawings. The busbar shall be NRTL listed for use as PBB and shall comply with TIA-607-C.
- D. Secondary Bonding Busbar (SBB): Predrilled rectangular bars of electro-tin plated copper, **1/4 by 2 inches** in cross section, minimum 12 inches in length or as indicated on Drawings. The busbar shall be NRTL listed as complying with UL 467, and shall comply with TIA-607-C.
- E. Rack Bonding Busbar (RBB): Comply with requirements for rack busbars in Section 271100 "Equipment Room Fittings."

## 2.5 IDENTIFICATION

- A. Comply with requirements for identification products in Section 270553 "Identification for Communications Systems."

**PART 3 - EXECUTION:**

**3.1 EXAMINATION**

- A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.
- B. Inspect the test results of the ac grounding system measured at the point of TBC connection.
- C. Prepare written report, endorsed by Installer, listing any conditions detrimental to performance of the Work.
- D. Proceed with connection of the TBC only after unsatisfactory conditions have been corrected.

**3.2 INSTALLATION**

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with TIA-607-C.

**3.3 APPLICATION**

- A. Conductors: Install solid conductor for **No. 8** AWG and smaller and stranded conductors for **No. 6** AWG and larger unless otherwise indicated.
  - 1. The bonding conductors between the PBB/SBB and structural steel of steel-frame buildings shall not be smaller than **No. 6** AWG.
- B. Conductor Terminations and Connections:
  - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
  - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
  - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
  - 4. Connections to Structural Steel: Welded connectors.
- C. Conductor Support:
  - 1. Secure grounding and bonding conductors at intervals of not less than 36 inches.
- D. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than ten times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.
3. Support at not more than 36-inch intervals.
4. Install grounding and bonding conductors in minimum 1-inch Schedule 80 PVC conduit where exposed to physical damage or where routed through building walls or footings. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.
  - a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a PBB/SBB.

### 3.4 GROUNDING ELECTRODE SYSTEM

- A. The Telecommunications Bonding Conductor (TBC) between the PBB and the Electrical service equipment ground busbar shall not be smaller than No. 1/0 AWG and not smaller than the Telecommunications Bonding Backbone (TBB).

### 3.5 BONDING BUSBARS

- A. Provide PBB in main telecommunications equipment room and locate to minimize length of TBC.
- B. Provide SBB in each telecom room.
- C. Install PBB/SBB horizontally, on insulated spacers 4 inches minimum from wall, 48 inches above finished floor unless otherwise indicated.
- D. Install RBB on rack or cabinet using stand-off block insulators to provide a minimum of 0.75 inches of separation for dissimilar metals and to facilitate conductor attachment to RBB. The RBB may be directly mounted/bonded to the rack or cabinet only if doing so allows adequate space for attaching grounding conductors and does not create a dissimilar metals reaction.

### 3.6 CONNECTIONS

- A. Bond all metallic equipment and pathways in every telecommunications room to the bonding busbar in that room, using insulated grounding conductors not smaller than No. 6 AWG.

- B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
- C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
  - 1. Use crimping tool and the die specific to the connector.
  - 2. Pretwist the conductor.
- D. Clean and apply an antioxidant compound to all bolted and compression connections.
- E. Building Entrance Protectors: Bond to the PBB/SBB with insulated bonding conductor.
- F. Busbar Interconnections: Interconnect all SBBs with the PBB using a continuous telecommunications bonding backbone (TBB). If more than one TBB is installed, interconnect TBBs using the backbone bonding conductor (BBC) conductor at the top floor and at every third floor in between. The telecommunications bonding backbone and backbone bonding conductor size shall not be less than 2 kcmils/linear foot of conductor length, up to a maximum size of 750 kcmil unless otherwise indicated.
- G. Telecommunications Enclosures and Equipment Racks/Cabinets: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Connect the Telecommunications Equipment Bonding Conductor (TEBC) to the Rack Bonding Busbar (RBB) and to the rack/cabinet using a Rack Bonding Conductor (RBC) and listed compression two hole lugs.
- H. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each SBB and PBB to the vertical steel of the building frame.
- I. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each PBB/SBB to the equipment ground bar of the panelboard.
- J. Shielded Cable: Bond the shield of shielded cable to the PBB/SBB in communications rooms and spaces. Comply with TIA-568.1-D and TIA-568.2-D when grounding shielded balanced twisted-pair cables.
- K. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the rack bonding busbar (RBB) using unit bonding conductors (UBC). Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.
- L. Ladder Rack and Cable Tray: Bond ladder rack/cable tray system to the PBB/SBB using manufacturer approved ground lugs and bonding conductors. Remove paint from the ladder rack/cable tray to ensure ground lugs contact bare metal.

- M. Metallic Conduits: In telecommunications rooms, bond metallic conduits longer than 24-inches to the PBB/SBB using insulated ground bushing sized for the conduit and ground conductor to be attached.

### 3.7 IDENTIFICATION

- A. Comply with requirements in Section 270553 "Identification for Communications Systems."

### 3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
  - 1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
  - 2. Two-point Continuity Test: Test the bonding connections of the system using a certified ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a PBB/SBB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.
    - a. Measure the resistance between the following:
      - 1) Each PBB/SBB to the nearest electrical equipment ground.
      - 2) Each PBB/SBB to the structural steel.
      - 3) PBB to each SBB.
      - 4) Structural steel to the electrical ground.
    - b. The maximum acceptable value of this bonding resistance is 100 milliohms.
  - 3. Test for ground loop leakage currents using a certified digital clamp-on earth ground tester, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
    - a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the PBB and in each SBB. Maximum acceptable ac current level is 1 A.
- B. Excessive Ground Resistance: If resistance to ground at the TBC exceeds 5 ohms, notify Engineer promptly and include recommendations to reduce ground resistance.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

**END OF SECTION**

## **SECTION 27 05 28**

### **PATHWAYS FOR COMMUNICATIONS SYSTEMS**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

- A. Comply with requirements in Section 260528 "Pathways for Electrical Systems" and as noted below.

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Metal conduits and fittings.
  - 2. Nonmetallic conduits and fittings.
  - 3. J-Hooks.
  - 4. Boxes, enclosures, and cabinets.
  - 5. Firestop

##### **1.3 DEFINITIONS**

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid conduit.
- C. IMC: Intermediate metal conduit.
- D. RTRC: Reinforced thermosetting resin conduit.

##### **1.4 SUBMITTALS**

- A. Comply with Section 270000 "General Requirements for Communications"

#### **PART 2 - PRODUCTS:**

##### **2.1 METAL CONDUITS AND FITTINGS**

- A. General Requirements for Metal Conduits and Fittings:
  - 1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

B. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Fittings for EMT:

- a. Material: Steel.
- b. Type: Compression.

C. Conduit Bodies

1. Telecommunications style with standards based internal bend radius control.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. General Requirements for Nonmetallic Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

2.3 J-HOOKS

A. Description: Comply with UL 2239, single and multi-tiered prefabricated sheet metal wide base cable supports with integral bend radius support for telecommunications cable.

B. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Erico Caddy

C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Galvanized steel.

E. J shape.

F. UL 2043 and CAN/ULC S102.2 listed and suitable for use in air handling spaces.

G. Pre-riveted assemblies allow for attachment to walls, ceilings, beams, threaded rods, drop wires and underfloor supports to meet requirements of a variety of applications.

2.4 BOXES, ENCLOSURES, AND CABINETS

A. Description: Enclosures for communications.

B. General Requirements for Boxes, Enclosures, and Cabinets:

- 1. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
- 2. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- 3. Device Box Dimensions:

- a. Minimum 4 inches square by 3-1/2 inches for 1-inch pathways.
  - b. Minimum 4-11/16 inches square by 3-1/2-inch deep box for pathways 1-1/4 inches and larger.
- 4. Gangable boxes are prohibited.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- F. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, type suitable for environmental conditions, with continuous-hinge cover with flush latch unless otherwise indicated.
  - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
  - 2. Nonmetallic Enclosures:
    - a. Material: **Fiberglass**.
  - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- G. Cabinets:
  - 1. NEMA 250, type suitable for environmental conditions, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
  - 2. Hinged door in front cover with flush latch and concealed hinge.
  - 3. Key latch to match panelboards.
  - 4. Metal barriers to separate wiring of different systems and voltage.
  - 5. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 2.5 MULTI-SERVICE FLOOR BOXES AND POKE-THROUGHS

- A. Description: Recessed multi-gang outlet with devices capable of supplying power, data, voice, and AV services.
- B. Manufacturers: Subject to compliance with requirements, provide product indicated on drawings or approved equal by one of the following:
  - 1. Wiremold
  - 2. Hubbell
  - 3. FSR
- C. UL 514A Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Floor Boxes and Poke-Thru Assemblies

1. Material: Cast metal or sheet metal with finished interior
2. Type: Fully adjustable before and after floor installation.
3. Shape: Rectangular or Round
4. Designed for use with industry standard wall plates, devices, and modular inserts.
5. Cover: Hinged, Gasketed, Die-cast, powder coated aluminum suitable for multiple floor surfaces. Provide covers with spring-loaded self-closing slide egress doors to reduce egress opening when cables are exiting and reduce trip hazards.
6. Painted with fusion-bonded epoxy where used in on-grade floor applications.
7. Classified for fire resistance up to 2 hours where used in rated floors.
8. Evaluated by UL to meet U.S. safety standards for scrub water exclusion.

2.6 FIRESTOP

- A. Manufacturers: Subject to compliance with requirements, provide products from the following:
1. Specified Technologies Inc (STI)
- B. Comply with testing requirements set forth in ASTM E814 or UL 1479.
- C. Fire rated cable pathways: Re-penetrable, maintenance-free cable management devices for use with cable bundles penetrating through fire rated walls or floors.
1. Shall contain a built-in fire sealing system sufficient to maintain the hourly rating of the fire rated wall or floor being penetrated.
  2. The system shall adjust to the installed cable loading and shall permit cables to be installed, removed, or retrofitted without the need to remove or reinstall firestop materials.
  3. Shall be engineered to allow two or more devices to be ganged together with wall plates for larger cable capacities.
- D. Fire-rated cable grommets: Molded, two-piece grommet with sealing membrane for use with single cables or small bundles at through or membrane wall penetrations.
1. System shall be installed around cables and shall lock tightly into the wall assembly.

**PART 3 - EXECUTION:**

3.1 PATHWAY APPLICATION

- A. Comply with requirements in Section 260533 "Raceways and Fittings for Electrical Systems" for pathway application except as noted below
- B. Minimum Pathway Size: 1-inch trade size.

1. For Cat6A applications: minimum 1-1/4-inch trade size.
- C. Pathway Fittings: Compatible with pathways and suitable for use and location.
  1. EMT: Use only steel compression fittings. Comply with NEMA FB 2.10.
- D. Install surface pathways only where indicated on Drawings.

### 3.2 INSTALLATION

- A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:
  1. NECA 1.
  2. NECA/BICSI 568.
  3. TIA-569-D.
  4. NECA 101
  5. NECA 102.
  6. NECA 105.
  7. NECA 111.
- B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- C. Comply with requirements in Section 2650529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- D. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Pathways and Cabling" for sleeves and sleeve seals for communications.
- E. Comply with requirements in Section 260533 "Raceways and Fittings for Electrical Systems" for installation of raceways and fittings except as noted below:
- F. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- G. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction.
- H. Utilize manufactured sweeps and long radius elbows for all optical-fiber cables.
- I. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.
- J. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.

- K. Install raceways a minimum of 6-inches from hot flues, steam pipes, hot water pipes, and other hot surfaces.
- L. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 100 feet .
- M. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- N. Minimum Bend Radius
  - a. For trade size conduits 2-inch or less, the inside bend radius shall be at least 6 times the internal diameter.
  - b. For trade size conduits greater than 2-inch, the inside bend radius shall be at least 10 times the internal diameter.
- O. Pull boxes should be readily accessible and should be installed in straight sections of conduit and not used in place of a bend.
- P. Conduits extending from a telecom room shall not serve more than three equipment outlet boxes.
- Q. J-Hooks:
  - 1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
  - 2. Shall be supported by dedicated support wires, threaded rod, beam clamps, or strut. Do not use ceiling grid support wire or support rods.
  - 3. Hook spacing shall allow no more than 6 inches of slack. The lowest point of the cables shall be no less than 6 inches adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
  - 4. Space hooks no more than 4 feet o.c. except for Cat6A installations where 3 foot spacing shall be used.
  - 5. Provide a hook at each change in direction.
  - 6. Do not exceed load ratings specified by manufacturer.
  - 7. Do not install J-hooks that cannot be maintained without removal of another system.
  - 8. Provide additional tiers where required to meet fill capacity and load rating requirements or to separate low voltage systems with varying voltage and power limitations.
- R. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

### 3.3 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping" and as outlined below.
- B. Coordinate location and proper selection of cast-in-place and drop-in Firestop devices with trade responsible for the work. Ensure device is installed before placement of concrete.
- C. Install firestop materials in accordance with UL Fire Resistance Directory and manufacturer's instructions.
- D. Seal all holes or voids made by penetrations to ensure an air and water-resistant seal.
- E. Affix adhesive wall label immediately adjacent to devices to communicate to futures installers and code authorities the manufacturer and UL system number of the device.
- F. Examine sealed penetration areas to ensure proper installation before concealing or enclosing areas. Keep areas of work accessible until inspection by applicable code authorities.

### 3.4 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or deterioration.
  - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
  - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.
- B. Protect installed cables in open cabling system
  - 1. Install temporary protection for cables in open pathways to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and J-hooks can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.

**END OF SECTION**

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## **SECTION 27 05 36**

### **CABLE TRAYS FOR COMMUNICATIONS SYSTEMS**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Wire-mesh cable tray.
  - 2. Cable tray accessories.

##### **1.3 SUBMITTALS**

- A. Comply with Section 270000 "General Requirements for Communications"

#### **PART 2 - PRODUCTS:**

##### **2.1 GENERAL REQUIREMENTS FOR CABLE TRAYS**

- A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
  - 1. Source Limitations: Obtain cable trays and components from single manufacturer.
- B. Sizes and Configurations: See Drawings for specific requirements for types, materials, sizes, and configurations.

##### **2.2 WIRE-MESH CABLE TRAY**

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Cablofil
- B. Description:

1. Configuration: steel wire mesh, complying with NEMA VE 1.
2. Minimum Width: **12 inches** unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: **4 inches** unless otherwise indicated on Drawings.
4. Straight Section Lengths: **10 feet**, except where shorter lengths are required to facilitate tray assembly.
5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
6. Splicing Assemblies: UL classified bolted type using serrated flange locknuts.
7. Splice-Plate Capacity: UL Classified splices located within support span shall not diminish rated loading capacity of cable tray.

C. Materials and Finishes:

1. Steel:
  - a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of **ASTM A 1011/A 1011M, SS, Grade 33**.
  - b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
  - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
  - d. Finish: Hot-dip galvanized after fabrication, complying with ASTM A123/A123 M, Class B2 for use in indoor/outdoor locations.
    - 1) Hardware: **Galvanized, ASTM B 633**
  - e. Finish: Electrogalvanized after fabrication, complying with ASTM B 633 for use in indoor locations.
    - 1) Hardware: Galvanized, ASTM B 633.
  - f. Finish: **Powder-coat enamel** paint.
    - 1) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint with a thickness of 1.2mils to 3.0 mils.
    - 2) Hardware: **Chromium-zinc plated, ASTM F 1136**.

2.3 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Barrier Strips: Same materials and finishes as for cable tray.
- C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

## 2.4 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to **NEMA VE 1**.

## **PART 3 - EXECUTION:**

### 3.1 CABLE TRAY INSTALLATION

- A. Install cable trays according to **NEMA VE 2**.
- B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
- C. Install cable trays to provide a minimum of 12" clear space above the top of the cable tray for cable installation and all splices are accessible for inspection and adjustment.
- D. Install cable trays to provide a minimum of 3 inch (6 inch recommended) clear space above ceiling tile and grid.
- E. Remove burrs and sharp edges from cable trays.
- F. Fasten cable tray supports to building structure.
- G. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems.
- H. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
- I. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
- J. Support assembly to prevent twisting from eccentric loading.
- K. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.
- L. Locate and install supports according to **NEMA VE 2**. Do not install more than one cable tray splice between supports.
- M. Support wire-basket cable trays with **trapeze hangers, or wall brackets**.
- N. Support trapeze **hangers** for wire-basket trays with **1/4-inch- or 3/8-inch** diameter rods.

- O. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
- P. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in **NEMA VE 2**. Space connectors and set gaps according to applicable standard.
- Q. Make changes in direction and elevation using manufacturer's recommended fittings and integral bend radius control.
- R. Make cable tray connections using manufacturer's recommended fittings.
- S. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- T. Install cable trays with enough workspace to permit access for installing cables.
- U. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels.
- V. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.
- W. Clamp covers on cable trays installed outdoors with heavy-duty clamps.
- X. Install warning signs in visible locations on or near cable trays after cable tray installation.

### 3.2 CABLE TRAY GROUNDING

- A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."
- B. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

### 3.3 CABLE INSTALLATION

- A. Install cables only when each cable tray run has been completed and inspected.
- B. Initial fill ratio shall not exceed 25%.

- C. Initial cable fill shall not exceed 50% of the manufacturer's listed load rating.
- D. Fasten cables on vertical runs with cable clamps or cable ties every 18 inches according to NEMA VE 2. Fasten cables on horizontal runs where required to maintain a neat and workmanlike installation.
- E. Tighten clamps and ties only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device and trim excess to prevent further tightening.
- F. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches.
- G. Provide radius drop-outs wherever multiple cables are existing the cable tray.
- H. In existing construction, remove inactive or dead cables from cable trays.

### 3.4 CONNECTIONS

- A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
- B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

### 3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections
  - 1. After installing cable trays, survey for compliance with requirements.
  - 2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
  - 3. Verify that communications cabling is separated from power circuits by barriers or are installed in separate cable trays.
  - 4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
  - 5. Remove dust deposits, trash of any description, and any blockage of tray ventilation.
  - 6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorquing in suspect areas.
  - 7. Check for improperly sized or installed bonding jumpers.
  - 8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.

9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

### 3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

**END OF SECTION**

## **SECTION 27 05 43**

### **UNDERGROUND PATHWAYS AND STRUCTURES FOR COMMUNICATION SYSTEMS**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Metal conduit and fittings, including GRC.
  - 2. Rigid nonmetallic duct.
  - 3. Duct accessories, including rigid innerduct and fabric innerduct.
  - 4. Polymer concrete handholes and boxes with polymer concrete cover.
  - 5. Utility structure accessories.

##### **1.3 DEFINITIONS**

- A. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.
- B. Duct Bank:
  - 1. Two or more ducts installed in parallel, with or without additional casing materials.
  - 2. Multiple duct banks.
- C. GRC: Galvanized rigid conduit.
- D. IMC: Intermediate metal conduit.
- E. RNC: Rigid nonmetallic conduit.
- F. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

#### 1.4 SUBMITTALS

- A. Comply with Section 270000 "General Requirements for Communications"

#### 1.5 FIELD CONDITIONS

- A. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

### **PART 2 - PRODUCTS:**

#### 2.1 METAL CONDUITS AND FITTINGS

- A. GRC: Comply with ANSI C80.1 and UL 6.
- B. General Requirements for Metal Conduits and Fittings:
  - 1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
  - 2. Comply with TIA-569-D and TIA-758-C.

#### 2.2 RIGID NONMETALLIC DUCTS

- A. Underground Plastic Utilities Duct: **Type EPC-80-PVC and Type EPC-40-PVC** RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.
- B. General Requirements for Nonmetallic Ducts and Fittings:
  - 1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
  - 2. Comply with TIA-569-D and TIA-758-C.
- C. Solvents and Adhesives: As recommended by duct manufacturer.

#### 2.3 DUCT ACCESSORIES

- A. Fabric Innerduct: Continuous, nylon resin polyester, **multi** -pocket fabric innerduct, with internal pull tape and tracer wire.
  - 1. Fittings
    - a. Conduit Plugs: compression type conduit plugs with locking nuts for sealing and securing one or more textile innerducts within a conduit.
    - b. Termination Bags: Inflation type bags for sealing and securing around one or more textile innerducts and cables within 2-inch outside diameter or larger conduit.

- 2. Pull Tape: measuring and pulling tape constructed of synthetic fiber, printed with accurate sequential footage marks. Color-coded.
  - B. Duct Spacers: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.
  - C. Underground-Detectable Line Warning Tape:
    - 1. Detectable Tape
      - a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground communications lines.
      - b. Printing on tape shall be permanent and shall not be damaged by burial operations.
      - c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
    - 2. Color and Printing
      - a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, and ANSI Z535.4.
      - b. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL-FIBER CABLE"
- 2.4 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER
- A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
  - B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
    - 1. Armorcast
    - 2. NewBasis
    - 3. Oldcastle
    - 4. Hubbell Quazite
  - C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
  - D. Color: **Gray**.
  - E. Configuration: Units shall be designed for flush burial and have **open** bottom unless otherwise indicated.
  - F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
  - G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

- H. Cover Legend: Molded lettering, to match campus standard.
- I. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
- J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- K. Handholes **48 inches wide by 48 inches long** and larger shall have factory-installed inserts for cable racks and pulling-in irons.

## 2.5 UTILITY STRUCTURE ACCESSORIES

- A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.
- B. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch-diameter eye, rated **2500-lbf** minimum tension.
- C. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
  - 1. Stanchions: Nominal 36 inches high by 4 inches wide, with minimum of nine holes for arm attachment.
  - 2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches with 450-lb minimum capacity to 20 inches with 250-lb minimum capacity. Top of arm shall be nominally 4 inches wide, and arm shall have slots along full length for cable ties.
- D. Cover Hooks: **Heavy duty, designed for lifts 60 lbf and greater. Two** required.

## **PART 3 - EXECUTION:**

### 3.1 PREPARATION

- A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise

locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

- C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Division 31. Remove and stockpile topsoil for reapplication according to Division 31.

### 3.2 UNDERGROUND DUCT APPLICATION

- A. Duct for Communications: **Type EPC-80-PVC** RNC, in direct-buried duct bank unless otherwise indicated.
- B. Underground Duct Crossing **Driveways, Roadways, and Railroads**: Type EPC-40-PVC RNC, encased in reinforced concrete.
- C. Stub-Ups for Communications: Concrete-encased **GRC**.

### 3.3 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for Communications:
  - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, **H-20** structural load rating.
  - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: **Polymer concrete, SCTE 77, Tier 22** structural load rating.
  - 3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: **Polymer concrete units, SCTE 77, Tier 8** structural load rating.
  - 4. Cover design load shall not exceed the design load of the handhole or box.

### 3.4 EARTHWORK

- A. Excavation and Backfill: Comply with Division 31 but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restoration: Replace area **immediately after backfilling is completed or after construction in immediate area is complete**.
- C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated.
- D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32.

- E. Cut and patch existing pavement in the path of underground duct, duct bank, and utility structures according to the "Cutting and Patching" Article in Division 01.

### 3.5 DUCT AND DUCT-BANK INSTALLATION

- A. Where indicated on Drawings, install duct, spacers, and accessories into the duct configuration shown. Duct installation requirements in this Section also apply to duct bank.
- B. Install duct and duct bank according to NEMA TCB 2 and TIA-758-C.
- C. Slope: Pitch duct and duct bank a minimum slope of 1:100 down toward manholes and handholes and away from buildings and equipment. Slope duct and duct bank from a high point in runs between two manholes, to drain in both directions.
- D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of **48 inches**, both horizontally and vertically, at other locations unless otherwise indicated.
  - 1. Duct and duct banks shall have maximum of two 90-degree bends, or the total of all bends shall be no more 180 degrees between pull points.
  - 2. Duct and duct banks shall have a maximum of 600 feet between pull points.
- E. Joints: Use solvent-cemented joints in duct and fittings, and make watertight according to manufacturer's written instructions. Stagger couplings, so those of adjacent ducts do not lie in same plane.
- F. End-Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 6 inches o.c. for 4-inch duct, and vary proportionately for other duct sizes.
  - 1. Begin change from regular spacing to end-bell spacing 10 feet from the end bell without reducing duct slope and without forming a trap in the line.
  - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight-line direct-buried duct and duct banks, with calculated expansion of more than 3/4 inch .
  - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- G. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches o.c. for 4-inch duct, and vary proportionately for other duct sizes.
  - 1. Begin change from regular spacing to terminator spacing 10 feet from the terminator without reducing duct slope and without forming a trap in the line.

2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight-line duct or duct bank, with calculated expansion of more than 3/4 inch.
- H. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet outside the building wall, without reducing duct slope away from the building or forming a trap in the duct. Use fittings manufactured for RNC duct-to-GRC conduit transition. Install GRC penetrations of building walls as specified in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."
- I. Sealing: Provide temporary closure at terminations of duct that has cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig hydrostatic pressure.
- J. Innerduct: Install immediately after mandreling duct. **Provide minimum three innerducts per duct** or as noted on drawings
- K. Pulling Cord: Install 200-lbf- test nylon cord in empty duct **and innerduct**.
- L. Concrete-Encased Duct and Duct Bank:
  1. Excavate trench bottom to provide firm and uniform support for duct or duct bank. Prepare trench bottoms as specified in Division 31 for pipes less than 6 inches in nominal diameter.
  2. Width: Excavate trench a minimum of 3 inches wider than duct or duct bank on each side.
  3. Depth: Install top of duct and duct bank at least 24 inches below finished grade in areas not subject to deliberate traffic, and at least 30 inches below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
  4. Support duct and duct bank on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
  5. Minimum Space Between Duct: 3 inches between edge of duct and exterior envelope wall, 2 inches between ducts for like services, and 4 inches between power and communications ducts.
  6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than **five** spacers per 20 feet of duct. Place spacers within 24 inches of duct ends. Stagger spacers approximately 6 inches between tiers. Secure spacers to earth and duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around duct or duct bank.
  7. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.
    - a. Couple GRC to duct with adapters designed for this purpose, and encase coupling with 3 inches of concrete.

- b. Stub-Ups to Indoor and Outdoor Equipment: Extend concrete-encased GRC horizontally a minimum of 60 inches from edge of base. Install insulated grounding bushings on terminations at equipment.
    - 1) Stub-ups shall be **minimum 4 inches above** finished floor and minimum 3 inches from conduit side to edge of slab.
  - 8. Reinforcement: Reinforce concrete-encased duct and duct bank where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
  - 9. Forms: Use trench walls to form side walls of duct and duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
  - 10. Concrete Cover: Install a minimum of 3 inches of concrete cover between edge of duct to exterior envelope wall, 2 inches between ducts, and 4 inches between power and communications duct.
  - 11. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
    - a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
    - b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch reinforcing-rod dowels extending a minimum of 18 inches into concrete on both sides of joint near corners of envelope.
  - 12. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Division 03. Place concrete carefully during pours to prevent voids under and between ducts and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto duct. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
  - M. Underground-Line Warning Tape: Bury **conducting** underground-line warning tape no less than 12 inches above all concrete-encased duct and duct bank **and approximately 12 inches below grade**. Align tape parallel to and within 3 inches of centerline of duct bank. Provide an additional warning tape for each 12-inch increment of duct-bank width over a nominal 18 inches. Space additional tapes 12 inches apart, horizontally.
- 3.6 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE
- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for

proper entrances. Use box extension if required to match depths of duct and duct bank, and seal joint between box and extension as recommended by manufacturer.

- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.
- D. Install handholes and boxes with bottom below frost line.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- F. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in **asphalt paving** and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring, encircling, and in contact with, enclosure, and with top surface screeded to top of box cover frame. Bottom of ring shall rest on **compacted earth**.
  - 1. Concrete: 3000 psi, 28-day strength, complying with Division 03 with a troweled finish.
  - 2. Dimensions: **10 inches wide by 12 inches deep**

### 3.7 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
  - 1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
  - 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch-long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
- B. Correct deficiencies and retest as specified above to demonstrate compliance.

### 3.8 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris.

**END OF SECTION**

## **SECTION 27 05 53**

### **IDENTIFICATION FOR COMMUNICATIONS SYSTEMS**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section Includes:
  - 1. Color and legend requirements for labels and signs.
  - 2. Labels.
  - 3. Signs.
  - 4. Cable ties.

##### **1.3 SUBMITTALS**

- A. Comply with Section 270000 "General Requirements for Communications"

#### **PART 2 - PRODUCTS:**

##### **2.1 GENERAL REQUIREMENTS**

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
  - 1. Brady
  - 2. Brother
  - 3. Dymo
  - 4. Hellerman Tyton
  - 5. Panduit

##### **2.2 PERFORMANCE REQUIREMENTS**

- A. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

- B. Labels shall be designed to remain permanently affixed and shall not fade under typical environmental conditions for the life of the product identified.
- C. Thermal Movements: Allow for thermal movements from ambient temperatures up to 120-deg F and surface temperatures up to 180-deg F.
- D. Provide mechanically printed black letters on a white field unless noted otherwise.

## 2.3 LABELS AND TAGS

- A. Heat Shrink Tubes: Flame-retardant shrinkable polyolefin tube with thermal transfer-printed identification label. Sized to suit diameter of cable and shrinks to fit firmly around cable it identifies. Full shrink recovery at a maximum of 200 deg F.
- B. Self-Adhesive Labels: Thermal transfer-printed, minimum 3-mil- thick, flexible labels with acrylic pressure-sensitive adhesive.
  - 1. Wraparound Vinyl or Nylon Cloth Type: Repositionable for wrapping and flagging flexible cables.
  - 2. Self-Laminating Vinyl Type: Clear wrap around tail shield laminates the entire printed legend for abrasion, UV-, weather- and chemical-resistance on flexible cables.
  - 3. General Purpose Polyester Type: for component labelling on flat surfaces.
- C. Marker Plate Tags: Thermal transfer printed, UV, weather, and chemical resistant polyolefin suitable for large cables or bundles. Pre-punched holes for attachment with cable ties.

## 2.4 SIGNS AND NAMEPLATES

- A. Laminated-Acrylic or Melamine-Plastic Signs and Nameplates:
  - 1. Engraved designation.
  - 2. Thickness:
    - a. For signs up to 20 sq. in., minimum 1/16 inch thick.
    - b. For signs larger than 20 sq. in. or 8 inches in length, 1/8 inch thick.
    - c. Engraved designation with black letters on white face
    - d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting. Exception shall be in locations where specifically approved contact type permanent adhesive may be used where screws cannot or should not penetrate substrate.
    - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

## 2.5 CABLE TIES

- A. Cable Ties: For attachment of marker plates, fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon, designed for continuous exposure to exterior sunlight.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.
5. UL 94 Flame Rating: 94V-0 in plenum locations

## 2.6 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

## **PART 3 - EXECUTION:**

### 3.1 COORDINATION

- A. Coordinate with Owner for approval of all labelling codes and schemes prior to creation and installation of labeling system.
- B. The final building room numbers selected by the Owner may vary from the room numbers indicated on the drawings.
- C. Use consistent designations throughout Project. If existing labelling scheme is in place, all labelling will defer to current scheme as to stay consistent with facility.

### 3.2 CABLING ADMINISTRATIVE DRAWINGS

- A. Provide professionally produced, scaled drawings using Computer Aided Design software identifying the location and labelling of Communications devices served out of each telecom room.
- B. Print on Arch D or E1 size paper and install in a prominent location in each equipment room and wiring closet.
- C. Provide rigid frame and 1/8-inch clear plastic protective overlay.
- D. Supply separate drawings for each Communications Room.

### 3.3 PREPARATION

- A. Self-Adhesive Identification Products: Before applying communications identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

### 3.4 INSTALLATION

- A. All labels shall be mechanically produced. Write-on labels are not permitted.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Apply identification devices to surfaces that require finish after completing finish work.
- E. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.
- F. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- G. Provide labels within 12 inches from cable termination points and secure tight to surface at a location with high visibility and accessibility for ease of identification after termination.
- H. Cable Ties: General purpose, except as listed below:
  - 1. Outdoors: UV-stabilized nylon.
  - 2. In Spaces Handling Environmental Air: Plenum rated.

### 3.5 IDENTIFICATION SCHEDULE

- A. All labeling and identification of system components shall follow campus standards where items are not defined in campus standard, comply with the following.
- B. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Equipment Room Racks, Cabinets, and Frames:
  - 1. Identify top and bottom, front and rear of each with self-adhesive engraved laminated plastic nameplate **containing rack or cabinet identifier (xy)**.
  - 2. Labels shall be no less than 2-inches in height with letters no less than 1-1/2" inches tall.
- D. Rack Patch Panels and Fiber Enclosures:
  - 1. Label each fiber enclosure and patch panel with a letter (-r) designating the order of the panel from the top of the cabinet or frame.
  - 2. Label each fiber enclosure adapter panel with self-adhesive label indicating range of port numbers.
  - 3. Label fiber enclosure cover with self-adhesive labels indicating each backbone cable link identifier including:
    - a. Near end port numbers

- b. Far end building identifier (b) for inter building cable
  - c. Far end Telecomm space identifier (fs)
  - d. Far end rack identifier (xy)
  - e. Panel identifier (-r)
  - f. Panel port numbers (:p)
- 4. Label each patch panel port or group of ports with a self-adhesive label or manufacturer provided insert indicating the following:
  - a. Room number of outlet being served.
  - b. Faceplate number.
  - c. Patch panel port number
- 5. Use manufacturer provided labels and mounting surfaces wherever possible.
- E. Wall Punchdown Blocks
  - 1. Label each cable termination position with a sequential number designator.
  - 2. Where insert type labels are used, install clear plastic cover over mechanically produced labels.
  - 3. Use manufacturer provided labels and mounting surfaces wherever possible.
- F. Backbone Cables:
  - 1. Label each cable with a thermal transfer marker tag indicating the backbone cable link identifier including the following:
    - a. Strand/pair count and cable type
    - b. Near end identifier and far end identifier including:
      - 1) Building identifier (b) for inter building cable
      - 2) Telecomm space identifier (fs)
      - 3) Rack identifier (xy)
      - 4) Panel identifier (-r)
      - 5) Port grouping(:p)
  - 2. Backbone cables shall be labeled at termination points and entrance/exit point of telecom space.
  - 3. Backbone cables in outside plant pathways: In addition to labels at termination points, label each backbone cable at all manholes, handholes, and pull points where cable enters and exits pathway.
- G. Horizontal Cables:
  - 1. Label each cable with a vinyl self-laminating label indicating the horizontal cabling link identifier including:
    - a. Room and faceplate number.
    - b. Telecomm Space identifier (fs)
    - c. Rack identifier (xy)
    - d. Patch Panel identifier (-r)
    - e. Patch Panel port number (:p)

2. Horizontal cables in outside plant pathways: In addition to labels at termination points, label each cable at manholes, handholes, and pull points where cable enters and exits pathway.
- H. Faceplates:
1. Label individual faceplates with self-adhesive labels or manufacturer provide insert. Place label at top of faceplate. Each faceplate shall be labeled with its individual, sequential designation, **numbered clockwise when entering room from primary egress**, indicating the following:
    - a. Room number of outlet
    - b. Faceplate number.
  2. Each individual jack within the same faceplate shall be labeled with its horizontal link identifier.
- I. Telecommunications Bonding Busbars and Conductors
1. Label each Busbar with a self-adhesive label indicating the following:
    - a. Telecomm space identifier (fs)
    - b. Busbar identifier
  2. Label each bonding conductor with a vinyl self-laminating label indicating the far end busbar or object identifier
  3. Label each bonding conductor at its attachment point with a thermal transfer marker tag with the following.
    - a. **WARNING: IF CABLE OR CONNECTOR IS LOOSE OR MUST BE REMOVED PLEASE CONTACT TELECOMMUNICATIONS MANAGER.**
  4. Warning labels shall be yellow marker plate type with black print.
- J. Underground duct and raceway
1. Label both ends of each underground duct and raceway with self-adhesive label indicating the following:
    - a. Pathway Identifier and sequence number
    - b. Far End Building Identifier (b)
    - c. Far End Telecomm Space Identifier (fs)
    - d. Far End Outdoor Space Identifier (T)
- K. Firestopping
1. Provide identification label to each side of the wall substrate and within 12 inches of the firestop penetration and indicate the following:
    - a. Fire-stop product/system used
    - b. Installation Company
    - c. Penetration Hour Rating
    - d. Installation Date

**END OF SECTION**

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## **SECTION 27 11 00**

### **COMMUNICATIONS EQUIPMENT ROOM FITTINGS**

#### **PART 1 - GENERAL:**

##### **1.1 SUMMARY**

###### **A. Section Includes:**

1. Backboards
2. 19-inch equipment racks.
3. Cable Management.
4. Ladder Rack/Cable Runway.
5. Rack Bonding Busbars.

###### **B. Related Requirements:**

1. Section 270000 "General Requirements for Communications"
2. Section 270536 "Cable Trays for Communications Systems" for cable trays and accessories.
3. Section 271300 "Communications Backbone Cabling" for copper, optical fiber, and coaxial data cabling associated with system panels and devices.
4. Section 271500 "Communications Horizontal Cabling" for copper and coaxial data cabling associated with system panels and devices.

##### **1.2 DEFINITIONS**

- A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.
- B. BICSI: Building Industry Consulting Service International.
- C. RCDD: Registered communications distribution designer.
- D. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.
- E. SBB: Secondary Bonding Busbar.
- F. PBB: Primary Bonding Busbar.
- G. RBB: Rack/Cabinet Bonding Busbar.

### 1.3 SUBMITTALS

- A. Comply with Section 270000 "General Requirements for Communications"

## **PART 2 - PRODUCTS:**

### 2.1 PERFORMANCE REQUIREMENTS

- A. UL Listed.
- B. RoHS compliant.

### 2.2 BACKBOARDS

- A. Backboards: AC grade plywood, fire-retardant treated, 3/4 by 48 by 96 inches.
- B. Backboard Paint: Light-colored fire-retardant paint.

### 2.3 19-INCH EQUIPMENT RACKS

- A. Description: Two- and four- post racks with threaded rails designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch equipment mounting with an opening of 17.72 inches between rails.
- B. Manufacturers: Subject to compliance with requirements, provide product indicated on drawings.
- C. General Requirements:
  - 1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
  - 2. Material: **Extruded aluminum**.
  - 3. Finish: Manufacturer's standard, baked-polyester powder coat.
  - 4. Color: **Black**.
- D. Floor-Mounted Racks:
  - 1. Overall Height: 84 inches or as indicated on Drawings.
  - 2. Overall Depth: 20 inches.
  - 3. Upright Depth: **3 inches**.
  - 4. Two-Post Load Rating: 1000 lb minimum.
  - 5. Four-Post Load Rating: 2000 lb minimum.
  - 6. Number of Rack Units per Rack: 45U or as indicated on Drawings.
    - a. Numbering: Every rack unit, on interior of rack.
  - 7. Threads: #12-24 universal hole pattern.

8. Provisions for attaching vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, **and a power strip**.
9. Base shall have a minimum of four mounting holes for permanent attachment to floor.
10. Top shall have provisions for attaching to cable tray or ceiling.
11. Self-leveling.
12. Four post rack shall be adjustable in depth in 1" increments.
13. Horizontal RBB for two post racks, Vertical RBB for four post racks.

## 2.4 CABLE MANAGEMENT

- A. Description: the cable management system shall accommodate the support and orderly routing of cabling within the communications rooms. Managers shall protect network equipment by controlling cable bend radius and providing cable strain relief.
- B. Source Limitations: Obtain rack/cabinet cable management from same manufacturer or alliance partner as rack/cabinet.
- C. Vertical Cable Management for Racks and Cabinets
  1. Double sided, front and rear
  2. Mounts to side of rack/cabinet
  3. Material: Steel panels and Plastic fingers
  4. Cable fingers with rounded edges at 1U intervals
  5. Height to match rack/cabinet
  6. Width: 6" or as indicated on drawings
  7. Cable distribution spools
  8. Color: Black
  9. Hinged front and rear doors
- D. Horizontal Cable Management for Racks and Cabinets
  1. Double sided, front and rear
  2. Cable finger with rounded edges along top and bottom surfaces
  3. Hinged front and rear cover
  4. Height: 2U or as indicated on drawings
  5. Color: Black
- E. Cable Support Rings: NTRL labeled. Cable supports shall be designed to prevent degradation of cable performance and pinch points that could damage cable.
  1. D-shaped wall mount loop designed for cable management
  2. Continuous loop for pull through cable installation or open slot insertion type cable installation
  3. Size: various pre-manufactured sizes
  4. Mounting holes for attachment with screws
  5. Material: Rigid nylon or zinc covered steel

## 2.5 LADDER RACK/CABLE RUNWAY

- A. Description: the ladder rack system shall accommodate the support and orderly routing of cabling within the communications rooms.
- B. Manufacturers: Subject to compliance with requirements, provide product indicated on drawings.
- C. General Requirements
  - 1. 1-1/2-inch-high by 3/8-inch-wide tubular steel
  - 2. Rung spacing shall be 12" on center minimum
  - 3. Color: Black powder coat
  - 4. Width: 12" or as indicated on Drawings
  - 5. Minimum linear cable bearing surface of 1-1/2 inches per linear foot.
- D. Fittings and Accessories:
  - 1. All fittings, supports, splices, etc. for the ladder rack system shall be installed to provide a complete assembly- including fasteners, hardware, and other items required to complete the installation as indicated on the drawings.
  - 2. Fittings shall be pre-manufactured and match rung size and spacing, material, and finish of ladder rack
  - 3. Splices and jumpers shall mechanically connect ladder rack sections and turns together to form an electrically continuous pathway

## 2.6 RACK BONDING BUSBAR

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Source Limitations: Obtain rack/cabinet grounding hardware from same manufacturer or alliance partner as rack/cabinet.
- C. Rack and Cabinet Bonding Busbars (RBB): Rectangular bars of electro-plated copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-606-B. Predrilling shall be with holes for use with lugs specified in this Section.
  - 1. Rack-Mounted Horizontal RBB: Designed for mounting in 19-inch equipment racks. Include stainless-steel or copper-plated hardware and insulator blocks for attachment to the rack.
  - 2. Rack-Mounted Vertical RBB: 72 or 36 inches long, with stainless-steel or copper-plated hardware and insulator blocks for attachment to rack.
- D. Stand-Off Brackets: Non-conductive nylon "L" brackets mounted to back channel of rack/cabinet, providing tie-down point for grounding and bonding cable runs.

**PART 3 - EXECUTION:**

**3.1 ENTRANCE FACILITIES**

- A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.
- B. Comply with requirements in Section 270528 "Pathways for Communications Systems" and Section 270543 "Underground Pathways and Structures for Communication Systems" for materials and installation requirements for raceways.

**3.2 INSTALLATION**

- A. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- B. Backboards:
  - 1. Install from 8-inches to 8-feet, 8-inches above finished floor on all walls of communications space. Ensure that fire-rating stamp is visible after installation.
  - 2. Paint all sides of backboard with two coats of fire-retardant paint, leaving fire rating stamp visible.
- C. Racks and Cabinets
  - 1. Provide racks and cabinets with a minimum 36-inches of clear, unobstructed space from the front and rear of the rack/cabinet.
  - 2. Floor mounted racks and cabinets shall be securely fastened to the structural floor using manufacturers recommended anchors or as required by local codes.
  - 3. Wall mounted racks and cabinets with hinged enclosures or frames shall be placed so that it can be accessed fully without obstruction by other building, storage, or architectural components. Follow the manufacturer's installation instructions for securing the rack/cabinet to the wall and backboard.
  - 4. Install and adjust to position all rack/cabinet accessories including cable management, power distribution, mounting rails, thermal management, and grounding prior to installing any equipment into the rack/cabinet.
- D. Cable Management
  - 1. Attach vertical cable managers to the side of the rack/cabinet using the manufacturer's installation instructions and included hardware.
  - 2. When a single vertical cable manager is used in between two racks/frames, attach the vertical cable manager to both racks/frames.
  - 3. Horizontal managers shall be located so that the number of ports (cables) that each manager supports shall not exceed each cable manager's cable fill capacity. A minimum of one horizontal cable manager shall be provide above each patch panel.
  - 4. The color of the rack(s)/cabinets(s) and cable manager(s) must match.

5. Covers shall be securely attached to the cable manager(s) after cabling is complete.
6. Space rings at maximum intervals of 12 inches along the path of the cables served.
7. Provide rings of sufficient size and quantity that no ring is utilized more than 25% of the rated capacity.

### 3.3 LADDER RACK/CABLE RUNWAY

- A. Secure to the structural ceiling, building truss system, wall, or floor and to the tops of equipment racks and/or cabinets using the manufacturer's recommended supports and appropriate installation hardware.
- B. Ladder rack splices will be made in mid-span, not over a support, with the manufacturer's recommended splice hardware.
- C. Ladder rack shall be supported every 5-feet or less in accordance with TIA-569-D. Ladder rack shall be supported within 2-feet of every splice and within 2-feet on both/all sides of every intersection. Support ladder rack within 2-feet on both sides of every change in elevation. Support ladder rack every 2-feet when attached vertically to a wall.
- D. Leave a minimum of 12-inches in between ladder rack and ceiling/building truss structure. Multiple tiers of ladder rack shall be installed with a minimum clearance of 12-inches in between each tier of ladder rack.
- E. Provide an elevation kit to maintain a minimum of 6-inches in between ladder rack and the tops of equipment racks and/or cabinets.
- F. Provide vertical ladder rack and supports where vertical distance between sleeves/pathways and horizontal ladder rack exceeds 5-feet.
- G. Within each telecommunications room, ladder rack should be bonded together with manufacturer's recommended ground straps, electrically continuous, and bonded to the PBB/SBB, unless otherwise noted in the specifications and contract documents. Ladder rack and turns shall be bonded across each splice with a bonding kit. Ladder rack shall be bonded to the PBB/SBB using an approved ground lug on the ladder rack and a minimum #6 grounding wire or as recommended by the AHJ. Remove paint from the ladder rack where bonding/ground lugs contact the ladder rack so that the lug will contact bare metal. Use antioxidant joint compound in between the bare metal on the ladder rack and ground lug. Use antioxidant joint compound in between the bus bar and the ground lug. Verify continuity through the bonds at splices and intersections between individual ladder rack sections and turns and through the bond to the PBB/SBB.
- H. Use a radius drop to guide cables wherever cable exits overhead ladder rack to access a rack, cabinet, or termination field. Provide a moveable cross member to attach and align the radius drop in between the welded cross members of a ladder rack.

- I. Cover the exposed ends of the ladder rack that do not terminate against a wall, the floor or the ceiling with end caps made from a rubberized material or an end closing kit.
- J. Provide touch-up paint color-matched to the finish on the ladder rack and will correct any minor cosmetic damage (chips, small scratches, etc.) resulting from normal handling during the installation process prior to delivery to the owner.
- K. Initial cable fill shall not exceed 2-inches in height and shall not exceed 25% of the interior area of the ladder rack. The interior area of ladder rack will be considered to be the width of the ladder rack multiplied by a height of 2-inches. Provide cable retaining posts where initial cable fill is exceeded.
- L. Do not exceed load ratings specified by manufacturer.

### 3.4 GROUNDING

- A. Provide bonding conductors and connectors in accordance with requirements in Section 270526 "Grounding and Bonding for Communications Systems."
- B. The rack bonding busbar (RBB) shall be cleaned and a compatible anti-oxidant shall be applied prior to fastening connectors to the busbar.
- C. Install RBB on rack or cabinet using block insulators to provide a minimum of 0.75 inches of separation.
- D. Connect RBB to either the Rack Bonding Conductor (RBC) or Telecommunications Equipment Bonding Conductor (TEBC) and to the rack using listed compression two-hole lugs.

### 3.5 IDENTIFICATION

- A. Provide component labelling in accordance with requirements in Section 270553 "Identification for Electrical Systems."

## END OF SECTION

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## **SECTION 27 13 00**

### **COMMUNICATIONS BACKBONE CABLING**

#### **PART 1 - GENERAL:**

##### **1.1 SUMMARY**

###### **A. Backbone Cabling Description:**

1. The backbone cabling system shall provide intra- and/or inter-building connections between communications equipment rooms, main terminal space, and entrance facilities in a multi room telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

###### **B. Section Includes:**

1. Single-mode, optical fiber cable.
2. Optical fiber cable hardware.

##### **1.2 SUBMITTALS**

- ###### **A. Comply with Section 270000 "General Requirements for Communications"**

#### **PART 2 - PRODUCTS:**

##### **2.1 GENERAL CABLE CHARACTERISTICS**

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

1. Plenum Applications: Type OFNP, OFCP, or CMP complying with NFPA 262
2. Non-plenum applications: Type OFNR, OFCR, or CMR complying with UL 1666
3. Wet Location or Outdoor Applications: OSP.

- ###### **B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.**

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

## 2.2 OPTICAL FIBER PERFORMANCE REQUIREMENTS

- A. General Performance: Optical Fiber Backbone cabling system shall comply with minimum performance values below as well as transmission standards in TIA-568.1-D and TIA-568.3-D, when tested according to test procedures in TIA-568.
- B. Manufacturers: Subject to compliance with requirements, provide product indicated on drawings.
- C. Jacket Identification
  - 1. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.
  - 2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
  - 3. Color:
    - a. OS2: Yellow
    - b. OSP: Black
- D. 9/125 Micrometer, Single-Mode, Optical Fiber (OS2)
  - 1. Comply with TIA-492CAAB for detailed specifications.
  - 2. Maximum Attenuation Coefficient: **0.4** dB/km at 1310 nm; **0.4**dB/km at 1550 nm.

## 2.3 INDOOR OPTICAL FIBER CABLE

- A. Description: Tight Buffer, **armored** distribution optical fiber cable suitable for use in indoor applications.
- B. Comply with ICEA S-83-596 for mechanical properties.
- C. Tight Buffer Cable Construction
  - 1. 900 µm thermoplastic buffered fibers
  - 2. Lightweight aramid yarn overall strength member.
  - 3. Ripcord to facilitate jacket removal.
  - 4. Multiple subunits with central dielectric strength member for cables with greater than 24 fibers.
  - 5. Flame retardant jacket.
- D. Armor
  - 1. Aluminum Interlocking Armor with additional outer jacket
  - 2. PVC All-dielectric non-conductive armor with additional outer jacket

## 2.4 OUTDOOR OPTICAL FIBER CABLE

- A. Description: Loose Tube, **armored** distribution optical fiber cable suitable for use in outdoor applications.
- B. Comply with ICEA S-87-640 for mechanical properties.

C. Loose-Tube Cable Construction

1. Gel-Free Loose Buffer Tubes with dry water blocking material
2. Aramid yarn overall strength member.
3. Ripcord to facilitate jacket removal.
4. Color coded buffer tubes stranded around central dielectric strength member
5. Water Blocking tape.
6. UV-, Moisture-resistant jacket.

D. Armor

1. Aluminum Interlocking Armor with additional outer jacket

2.5 OPTICAL FIBER CABLE HARDWARE

A. Source Limitations: Obtain optical fiber cable hardware from same manufacturer or alliance partner as optical fiber cable.

B. Standards:

1. Comply with Fiber Optic Connector Intermateability Standard (FOCIS) specifications of the TIA-604 series.
2. Comply with TIA-568.3-D.

C. Modular Patch Panels:

1. Rack mount, metal patch panel with numbered units that accept adapter panels or individual adapter modules.

D. Fiber Enclosures

1. Steel Enclosure used to protect and manage fiber optic terminations and splices.
2. Provide integral bend radius control and cable management for fiber patch cords.
3. Include grommets, cable ties, spools, and brackets to provide strain relief for cable routing.
4. Rack Mount
  - a. Enclosure with slide-out, tilt down tray suitable for installation in standard EIA 19" rack rails
  - b. Front and rear access with latching hinged doors.

E. Fiber Adapter Panels

1. Snap-in installation into fiber enclosures and fiber patch panels
2. Contains compatible simplex or duplex fiber optic adapter modules and meets or exceeds TIA-568.3-D requirements.

F. Adapter Modules:

1. Female; simplex and duplex; ceramic sleeve, modular adapter designed for mating two fiber optic connectors.
2. Follow the TIA-568.3-D suggested color identification scheme
3. Designed to snap into an adapter panel or faceplate.

- G. Connectors:
  - 1. Pre-polished, factory terminated, **Fusion** splice-on connectors with integral strain relief boot for termination of 900  $\mu$ m buffered fibers.
  - 2. Type: **Type LC complying with TIA-604-10-B**, connectors.
  - 3. Maximum Insertion loss: **0.4** dB for multi-mode or single-mode connectors.
- H. Pigtail Assemblies:
  - 1. Multi-leg, factory terminated, fiber connector assembly for termination of tight buffered or loose tube cables.
  - 2. Maximum Insertion loss: **0.4** dB for multi-mode or single-mode connectors.
- I. Buffer Tube Fan-Out Kits:
  - 1. 900  $\mu$ m fan out assembly for use when terminating 250  $\mu$ m coated fibers in loose buffer tubes.
  - 2. Color coded to match fiber color scheme.
  - 3. Rated for installed environment.
- J. Patch Cords: Factory-made, push-pull type, dual-fiber cables in varying lengths.
- K. Splices
  - 1. Type: Fusion
  - 2. Maximum Insertion loss: **0.3** dB for multi-mode or single-mode splices.
  - 3. Provide heat shrinkable sleeve to secure and protect splice while maintaining individual access.
- L. Splice Trays
  - 1. Metal enclosure with integral strain relief, cable management, and fiber spooling for protection of splices.
  - 2. For use with both loose-tube and tight buffered fiber optic cable in indoor fiber enclosures or outdoor splice enclosures

### **PART 3 - EXECUTION:**

#### **3.1 WIRING METHODS**

- A. Wiring Method: Install cables in raceways and cable trays **except in accessible ceiling spaces where unenclosed wiring method may be used**. Conceal raceway and cables except in unfinished spaces.
  - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
  - 2. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

### 3.2 GENERAL REQUIREMENTS FOR BACKBONE CABLING INSTALLATION

- A. Comply with NECA 1, NECA 301, and NECA/BICSI 568.
- B. Terminate all cables; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
- C. Cables may not be spliced unless noted otherwise.
- D. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
- E. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
- F. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
- G. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
- H. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
- I. In each telecommunications space, securely fasten all backbone cables and provide a 30-foot- long service.
- J. Backbone cables shall be installed separately from horizontal cables:
  - 1. Where backbone cables and horizontal cables are installed in a cable tray or wireway, backbone cables shall be installed first and segregated from the horizontal cables.
  - 2. Where cables are routed using conduits or j-hooks, the backbone and horizontal cables shall be installed in separate conduits/j-hooks.
- K. Open Cable Installation
  - 1. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
  - 2. Cable and support hardware shall not obstruct access to panels, equipment, valves, boxes, or other control devices.
- L. Support vertical runs of cable with a wire mesh grip, messenger strand, cable ladder, or other method to provide proper support for the weight of the cables.

- M. Provide innerduct for installation of new cabling in conduit with existing cables. Do not install new cabling in same conduit or innerduct with existing cables.
- N. Under no circumstances shall the cable or patch cords be painted, treated, or covered with other material unless approved by the manufacturer, Owner, and Engineer.

### 3.3 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

- A. Strip each fiber cable upon entering the splice tray and route the individual fibers in the splice tray.
- B. Provide 20-inch slack loop and neatly coil fiber within the fiber splice tray or enclosure. Unprotected fiber shall not be allowed external to the fiber enclosure.
- C. Attach each individual cable to the respective fiber enclosure by mechanical means. The cables strength member shall be securely attached the cable strain relief bracket in the enclosure.
- D. A maximum of 12 strands shall be spliced in each tray.
- E. All spare strands shall be installed into spare splice trays or adapter panels.
- F. Provide blank adapter panels for all un-used spaces in fiber enclosures.
- G. After system testing and acceptance, seal outdoor splice closures and flash test with a maximum of 10 PSI to ensure water-proof seal.

### 3.4 IDENTIFICATION

- A. Provide identification of cabling and devices in accordance with Section 270533 "Identification for Communications Systems".

### 3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections on all new and modified cabling and termination hardware.
- B. Tests and Inspections:
  - 1. Visually inspect optical fiber and twisted pair jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding, and inspect cabling connections for compliance with TIA-568.
  - 2. Visually confirm Category marking of outlets, cover plates, outlet/connectors, and patch panels.
  - 3. Visually inspect cable placement, cable termination, cable bend radius, grounding and bonding, equipment and patch cords, and labeling of all components.

4. Field-test instruments shall be approved by the cable manufacturer, be within the calibration period recommended by the instrument manufacturer, and meet a minimum Level III accuracy in accordance with TIA-1152-A. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
5. Optical Fiber Performance Tests:
  - a. Optical Fiber Cable Tests shall be performed on all fiber strands.
  - b. Fiber end faces shall be inspected using a video scope and recorded in the memory of the test instrument for subsequent reporting.
  - c. Link Tier 1 Attenuation Tests:
    - 1) Testing shall be performed on each cabling segment (connector to connector) individually as its installed and on each end to end cabling channel (equipment to equipment) for final acceptance.
    - 2) Multimode backbone link measurements: Test at 850 and 1300 nm in both directions according to TIA-526-14-B, Method B, one-cord reference method, with an Encircled Flux compliant launch.
    - 3) Single-mode backbone link measurements: Test at 1310 and 1550 nm in both directions according to TIA-526-7, Method A.1, one-cord reference method.
    - 4) Attenuation test results shall be less than those calculated according to equation in TIA-568 with a maximum allowable connector loss of 0.4dB and maximum allowable splice loss of 0.3dB.
  - d. For all OSP cable, backbone cable with splices, or fiber strands that exceed specified maximum power loss, perform Tier 2 testing utilizing an OTDR bi-directional tester at the wavelengths specified above to ensure uniformity of cable attenuation, connector insertion loss and reflectance. Overall, the OTDR test results shall be made up of the wavelength of the conducted test, the link length, attenuation, cable identification, the locations of the near end, the far end and each splice point or points of discontinuity.
  - e. Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with Clause E.5.3 of TIA-568. The polarity of the paired duplex fibers shall be verified using an OLTS.
6. Final Verification Tests: Perform verification tests for optical fiber after the complete communication cabling and workstation outlet/connectors are installed.
  - a. Voice Tests: After dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
  - b. Data Tests: After Owner's Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

- C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report or shall be transferred from the instrument to the computer, printed, and submitted unaltered.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections. Marginal passes are not acceptable.
- E. Remove, replace, and re-test cabling and terminations where test results indicate that it does not comply with specified requirements.
- F. Prepare test and inspection reports.
- G. The Engineer may request that a 10% random field re-test be conducted on the cabling system, at no additional cost, to verify documented findings. Tests shall conform to the requirements listed above. If findings contradict the documentation submitted by the contractor, additional testing can be requested to the extent deemed necessary by the Engineer, including a 100% re-test. Any re-testing shall be at no additional cost to the Owner.

**END OF SECTION**

## **SECTION 27 15 00**

### **COMMUNICATIONS HORIZONTAL CABLING**

#### **PART 1 - GENERAL:**

##### **1.1 SUMMARY**

###### **A. Horizontal Cabling Description**

1. Horizontal cable and its connecting hardware provide means of transporting signals between a telecommunications outlet/connector and the horizontal cross connect located in a telecommunications room. The cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection. This cabling and its connecting hardware are called a "permanent link," a term that is used in the testing protocols.
2. A work area is approximately 100 sq. ft., and includes the components that extend from the equipment outlets to the station equipment.
3. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

###### **B. Section Includes:**

1. Twisted Pair Cabling
2. Twisted pair cable connecting hardware, including patch panels and cross connects
3. Telecommunications outlets/connectors, including plugs and jacks.
4. Grounding provisions for twisted pair cable.
5. Source quality control requirements for twisted pair cable.

##### **1.2 DEFINITIONS**

- A. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
- B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- C. EMI: Electromagnetic interference.
- D. IDC: Insulation displacement connector.

- E. LAN: Local area network.
- F. Jack: Also commonly called an "outlet," it is the fixed, female connector.
- G. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.
- H. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- I. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- J. UTP: Unscreened (unshielded) twisted pair.

### 1.3 SUBMITTALS

- A. Comply with Section 270000 "General Requirements for Communications"

## **PART 2 - PRODUCTS:**

### 2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with minimum performance values listed herein and transmission standards in TIA-568-.1-D, when tested according to test procedures of this standard.

### 2.2 GENERAL CABLE CHARACTERISTICS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard, UL 444, and NFPA 70 for the following types:
  - 1. Wet Location and Outdoor Applications: OSP.
- B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
  - 1. Flame-Spread Index: **25** or less.
  - 2. Smoke-Developed Index: **50** or less.
- C. RoHS compliant.

### 2.3 ENHANCED PERFORMANCE CATEGORY 6 TWISTED PAIR CABLE

- A. Description: Four-pair, balanced-twisted pair cable, with internal separator, certified to meet transmission characteristics of Category 6 cable at frequencies up to 350MHz and minimum +3 dB margin for internal crosstalk parameters.

- B. Manufacturers: Subject to compliance with requirements, provide product indicated **on drawings**.
- C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568.2-D for Category 6 cables.
- D. Conductors: 100-ohm, 23 AWG solid copper.
- E. Shielding/Screening: Unshielded twisted pairs (UTP) unless noted otherwise.
- F. Jacket: **Blue** thermoplastic unless noted otherwise.

## 2.4 TWISTED PAIR CABLE HARDWARE

- A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.
- B. General Requirements for Twisted Pair Cable Hardware:
  - 1. Comply with the performance requirements of the twisted pair cabling.
  - 2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
  - 3. Cables shall be terminated with connecting hardware of same category or higher.
- C. Source Limitations: Obtain twisted pair cable hardware from same manufacturer or alliance partner as twisted pair cable.
- D. Expansion Criteria: Unless otherwise noted, provide spare positions in cross connects and patch panels to accommodate 20% future growth.
- E. Connecting Blocks:
  - 1. 110-style IDC
  - 2. 50, 100, and 300 pair footprint.
  - 3. Supports termination of 22-24 AWG solid conductors.
  - 4. Provide blocks for the number of cables terminated on the block, plus **25** percent spare, integral with connector bodies, including plugs and jacks where indicated.
- F. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between horizontal and backbone cables.
  - 1. Number of Terminals per Field: **One** for each conductor in assigned cables.
  - 2. Management rings shall be provided between vertical columns of blocks to provide management of cross connect wire.
- G. Modular Patch Panel: Metal patch panel with numbered jack units that accept modular type connectors at each jack location for permanent termination of pair groups of installed cables.

1. Features:
    - a. Universal T568A and T568B wiring labels.
    - b. Labeling areas adjacent to conductors.
    - c. Replaceable connectors.
    - d. 24 or 48 ports.
    - e. Strain Relief Bar
  2. Construction: 16-gauge steel and mountable on 19-inch equipment racks.
  3. Number of Jacks per Field: One for each four-pair cable indicated, plus spares and blank positions adequate to suit specified expansion criteria.
- H. Patch Cords: Factory-made, four-pair cables in various lengths; terminated with an eight-position modular plug at each end.
1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
  2. Patch cords shall have color-coded boots for circuit identification.
  3. Patch cords shall match performance rating of horizontal link.
- I. Plugs and Plug Assemblies:
1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable, rated to match performance of horizontal link.
  2. Standard: Comply with TIA-568.2-D.
  3. Marked to indicate transmission performance.
- J. Modular Jacks and Jack Assemblies:
1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable, rated to match performance of horizontal link.
  2. Designed to snap-in to a patch panel or faceplate.
  3. Standard: Comply with TIA-568.2-D.
  4. Marked to indicate transmission performance.
- K. Faceplate:
1. **Four** port, vertical single gang faceplates designed to mount to single gang wall boxes.
  2. **Eight** port, vertical double gang faceplates designed to mount to double gang wall boxes.
  3. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
  4. Metal Faceplate: **Stainless steel**, complying with requirements in Section 262726 "Wiring Devices."
  5. For use with snap-in modular jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.

L. Legend:

1. Machine printed, in the field, using adhesive-tape label.

**PART 3 - EXECUTION:**

3.1 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters **and except in accessible ceiling spaces, where unenclosed wiring method may be used.** Conceal raceway and cables, except in unfinished spaces.
  1. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF PATHWAYS

- A. Comply with requirements for demarcation point, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings."
- B. Comply with Section 270528 "Pathways for Communications Systems."
- C. Comply with Section 270536 "Cable Trays for Communications Systems."
- D. Drawings indicate general arrangement of pathways and fittings.

3.3 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

- A. General Requirements for Cabling:
  1. A minimum of two equipment jacks shall be provided for each work area outlet unless noted otherwise.
  2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
  3. Bridged taps and splices shall not be installed in the horizontal cabling.
  4. Do not untwist twisted pair cables more than 1/2 inch from the point of termination to maintain cable geometry.
  5. The cable jacket shall be maintained to within 1-inch of the termination point.

6. Horizontal cabling shall have the following minimum bending radii
  - a. Twisted Pair Cable: 4 times the outside diameter of the cable.
  - b. Coax Cable: 10 times the outside diameter of the cable.
7. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
8. Cables shall be coiled in the outlet boxes if adequate space is present to house the cable coil without exceeding the cable bend radius.
9. No more than 12-inches of twisted pair and 36-inches of fiber optic cable shall be stored in an outlet box or modular furniture raceway after termination. Excess slack shall be loosely stored in the ceiling above each drop location.
10. In the telecommunications room, provide minimum 10-foot of slack for all horizontal cables and dress/store on ladder rack system without exceeding the cable bend radius.
11. Twisted pair and coaxial cable slack should be stored in a Figure 8, "U" or "S" pattern.
12. MUTOAs shall not be used as a cross-connect point.
13. Provide consolidation point and cabling listed for wet locations at floor boxes in slab-on grade construction.:
  - a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
  - b. Locate consolidation points for twisted-pair cables at least 49 feet from communications equipment room.
14. The same orientation and positioning of jacks and connectors shall be utilized throughout the installation.
15. Provide blank filler inserts for all unused work area faceplate ports.
16. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
17. Cables shall be neatly bundled and dressed into groups of no more than 48 cables and routed from the point of entrance into the telecommunications space to their respective patch panel or connecting block.
18. Each patch panel or connecting block shall be fed by individual bundles separated and dressed with hook and loop straps.
19. Install lacing bars and distribution spools to restrain cables, prevent straining connections, and maintain minimum bending radii.
20. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
21. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
22. Pulling Cable: Comply with current version of BICSI Information Technology Systems Installation Methods Manual (ITSIMM), "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.
23. Under no circumstances shall the cable or patch cords be painted, treated, or covered with other material unless approved by the manufacturer, Owner, and Engineer.

B. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable management in telecommunications spaces with terminating hardware and interconnection equipment.
2. Cable shall not be run through structural members, attached to ceiling grid/luminaire supports, or in contact with pipes, ducts, or other potentially damaging items.
3. Cable and support hardware shall not obstruct access to panels, equipment, valves, boxes, or other control devices.

C. Group connecting hardware for cables into separate logical fields.

D. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
  - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
  - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
  - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
  - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
  - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

### 3.4 IDENTIFICATION

- A. Provide identification of cabling and devices in accordance with Section 270533 "Identification for Communications Systems".

### 3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections on all new and modified cabling and termination hardware.
- B. Tests and Inspections:
  - 1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568.1-D.
  - 2. Visually confirm Category marking of outlets, cover plates, outlet/connectors, and patch panels.
  - 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
  - 4. Field-test instruments shall be approved by the cable manufacturer, be within the calibration period recommended by the instrument manufacturer, and meet a minimum Level IV accuracy in accordance with TIA-1152-A. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
  - 5. Twisted Pair Continuity Tests:
    - a. Test twisted pair cabling for shorts, opens, intermittent faults, polarity and pair reversals, crossed pairs, and split pairs. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
  - 6. Twisted Pair Performance Tests:
    - a. Test each cable link to the performance requirements outlined in this specification and manufacturer's warranty requirements. Perform the following tests according to TIA-568.1-D, TIA-568.2-D, and TIA-1152-A:
      - 1) Wire Map
      - 2) Length (physical vs. electrical, and length requirements).
      - 3) DC resistance.
      - 4) DC resistance unbalance.
      - 5) Insertion loss.
      - 6) Near-end crosstalk (NEXT) loss.
      - 7) Power sum near-end crosstalk (PSNEXT) loss.
      - 8) Equal-level far-end crosstalk (ELFEXT).
      - 9) Power sum equal-level far-end crosstalk (PSELFEXT).
      - 10) Return loss.
      - 11) Propagation delay.
      - 12) Delay skew.

7. Final Verification Tests: Perform verification tests for UTP systems after the complete communication cabling and workstation outlet/connectors are installed.
  - a. Voice Tests: After dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
  - b. Data Tests: After Owner's Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.
- C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, printed, and submitted unaltered.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections. Marginal passes are not acceptable.
- E. Remove, replace, and re-test cabling and terminations where test results indicate that they do not comply with specified requirements.
- F. Prepare test and inspection reports.
- G. The Engineer may request that a 10% random field re-test be conducted on the cabling system, at no additional cost, to verify documented findings. Tests shall conform to the requirements listed above. If findings contradict the documentation submitted by the contractor, additional testing can be requested to the extent deemed necessary by the Engineer, including a 100% re-test. Any re-testing shall be at no additional cost to the Owner.

**END OF SECTION**

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## **SECTION 28 46 21.11**

### **ADDRESSABLE FIRE-ALARM SYSTEMS**

#### **PART 1 - GENERAL:**

##### **1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Division 26 for basic materials and methods, and electrical identification.
- C. Division 22 for installation of duct type smoke detectors and control wiring from Fire Alarm control equipment to mechanical fans, dampers, and control devices.

##### **1.2 SUMMARY**

- A. System Description:
- B. Section Includes:
  - 1. Fire-alarm control unit.
  - 2. Manual fire-alarm boxes.
  - 3. System smoke detectors.
  - 4. Heat detectors.
  - 5. Notification appliances.
  - 6. Device guards.
  - 7. Magnetic door holders.
  - 8. Remote annunciator.
  - 9. Addressable interface device.
  - 10. Network communications.

##### **1.3 DEFINITIONS**

- A. EMT: Electrical Metallic Tubing.
- B. FACP: Fire Alarm Control Panel.
- C. HLI: High Level Interface.
- D. NICET: National Institute for Certification in Engineering Technologies.
- E. PC: Personal computer.

- F. VESDA: Very Early Smoke-Detection Apparatus.

#### 1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

- B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include floor plans, drawn to a scale not less than 1/8-inch equals 1 foot, which clearly show locations of device, equipment, risers, panels, electrical power connections, approximate location of conduit runs, and other information required to clearly describe the proposed system.
3. Include enlarged plans, drawn to a scale not less than 1/4-inch equals 1 foot, for equipment rooms, fire command center, and security office with dimensioned layout of equipment therein.
4. Include scaled elevations, sections, details, and attachments to other work.
5. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
6. Detail assembly and support requirements.
7. Include voltage drop calculations for notification-appliance circuits.
8. Include battery-size calculations showing battery capacity and supervisory and alarm standby power requirements.
9. Include input/output matrix.
10. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
11. Include performance parameters and installation details for each detector.
12. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
13. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
  - a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
  - b. Show field wiring required for HVAC unit shutdown on alarm.
  - c. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.
  - d. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' smoke-evacuation system.
  - e. Locate detectors according to manufacturer's written recommendations.

- f. Show air-sampling detector pipe routing.
- 14. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
- 15. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.
- C. Submittals shall be approved by authorities having jurisdiction (AHJ) prior to submitting them to Architect.
- D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional responsible for their preparation.
  - 1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
  - 2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
  - 3. Indicate audible appliances required to produce square wave signal per NFPA 72.

#### 1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Certified Installers, including names, license numbers, and certifications.
- B. Sample Warranty

#### 1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.
  - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following **and deliver copies to authorities having jurisdiction**:
    - a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
    - b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.

- c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
- d. Riser diagram.
- e. Device addresses.
- f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
- g. Record copy of site-specific software.
- h. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
  - 1) Equipment tested.
  - 2) Frequency of testing of installed components.
  - 3) Frequency of inspection of installed components.
  - 4) Requirements and recommendations related to results of maintenance.
  - 5) Manufacturer's user training manuals.
- i. Manufacturer's required maintenance related to system warranty requirements.
- j. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

- 1. Software operating and upgrade manuals.
- 2. Program Software Backup: On magnetic media or compact disk, complete with data files.
- 3. Device address list.
- 4. Printout of software application and graphic screens.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- 1. Lamps for Strobe Units: Quantity equal to **10** percent of amount installed, but no fewer than one unit.
  - 2. Smoke Detectors, Fire Detectors: Quantity equal to **10** percent of amount of each type installed, but no fewer than one unit of each type.
  - 3. Detector Bases: Quantity equal to **two** percent of amount of each type installed, but no fewer than one unit of each type.
  - 4. Keys and Tools: One extra set for access to locked or tamper-proofed components.
  - 5. Audible and Visual Notification Appliances: **One** of each type installed.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications

1. Manufacturer shall maintain an authorized distributor within 100 miles of the project location which stocks a full complement of parts for all equipment to be furnished.

B. Installer Qualifications:

1. Be in business a minimum of 5 continuous years
2. Contractor shall demonstrate satisfaction of sound financial condition and can be adequately bonded and insured.
3. Possess those licenses/permits required to perform telecommunications installations in the specified jurisdiction.
4. Personnel knowledgeable in local, state, province and national codes, and regulations. All work shall comply with the latest revision of the codes or regulations. When conflict exists between local or national codes or regulations, the most stringent codes or regulations shall be followed.
5. Must possess current liability insurance certificates.
6. Must have personnel fluent in the use of Computer Aided Design and possess and operate CAD software using .DWG format.
7. The Contractor shall be a certified installer in good standing with the approved manufacturer.

C. Project Personnel Requirements: Contractor must have the following certified full-time employees on staff and assigned to the project.

1. Project Engineer: Preparation of shop drawings, cabling administration drawings, and field-testing program development by a NICET certified Level IV technician who shall be trained and certified in fire alarm system design by the approved manufacturer and licensed by the authorities having jurisdiction.
2. Technician: Minimum NICET certified Level III technician who shall provide all devices, connections, and programming for the fire alarm system. Technician shall be licensed by the authorities having jurisdiction and be present at all times when work of this Section is performed at the project site.

D. References: The Customer may, with full cooperation of The Contractor, visit client installations to observe equipment operations and consult with references. Specified visits and discussion shall be arranged through The Contractor; however, The Contractor personnel shall not be present during discussions with references. The Contractor must provide a minimum of three (3) reference accounts at which similar work, both in scope and design, have been completed by The Contractor within the last two (2) years.

E. NFPA Certification: All devices used as part of the Fire Alarm System shall be listed under the appropriate category according to NFPA 72 by an NRTL (nationally recognized testing laboratory).

## 1.9 PROJECT CONDITIONS

- A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

- B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
  - 1. Notify **Engineer and Owner** no fewer than 10 days in advance of proposed interruption of fire-alarm service.
  - 2. Identify specific locations affected by interruption, circuits which may be inoperable during the outage, and the length of time the system will be impaired.
  - 3. Do not proceed with interruption of fire-alarm service without the **Owner's** written permission.
- C. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

#### 1.10 SEQUENCING AND SCHEDULING

- A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.
- B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

#### 1.11 WARRANTY

- A. The Contractor shall warranty the installation and workmanship for a period of one (1) year from substantial completion.
- B. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship for a period of five (5) years from date of Substantial Completion.
- C. Warranty service shall be provided by a trained specialist of the equipment manufacturer. The specialist shall be based in a fully-staffed branch office located within 100 miles from the job site.

### **PART 2 - PRODUCTS:**

#### 2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
  - 1. Edwards EST

- B. For renovation or extension of existing building systems, match existing system.
- C. Being listed as an acceptable Manufacturer in no way relieves obligation of the Contractor to provide all equipment and features in accordance with these specifications

## 2.2 SYSTEM DESCRIPTION

- A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.
- B. Noncoded, **UL-certified** addressable system, with multiplexed signal transmission and **voice**/strobe evacuation.
- C. Automatic sensitivity control of certain smoke detectors.
- D. All components provided shall be listed for use with the selected system.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

## 2.3 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one or more of the following devices **and systems**:
  - 1. Manual stations.
  - 2. Heat detectors.
  - 3. Smoke detectors.
  - 4. Duct smoke detectors.
  - 5. Carbon monoxide detectors.
  - 6. Automatic sprinkler system water flow.
  - 7. Fire standpipe system.
  - 8. Fire pump running.
- B. Fire-alarm signal shall initiate the following actions:
  - 1. Continuously operate alarm notification appliances, **including voice evacuation notices**.
  - 2. Identify alarm and specific initiating device at fire-alarm control unit, **connected network control panels, off-premises network control panels, and remote annunciators**.
  - 3. Transmit an alarm signal to the campus receiving station.
  - 4. Unlock electric door locks in designated egress paths.
  - 5. Release fire and smoke doors held open by magnetic door holders.

6. Activate voice/alarm communication system.
  7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
  8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
  9. Recall elevators to primary or alternate recall floors.
  10. Activate elevator power shunt trip.
  11. Record events in the system memory.
- C. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Valve supervisory switch.
  2. Elevator shunt-trip supervision.
  3. Fire pump running.
  4. Fire-pump loss of power.
  5. Fire-pump power phase reversal.
  6. User disabling of zones or individual devices.
  7. Loss of communication with any panel on the network.
- D. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
  2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
  3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
  4. Loss of primary power at fire-alarm control unit.
  5. Ground or a single break in internal circuits of fire-alarm control unit.
  6. Abnormal ac voltage at fire-alarm control unit.
  7. Break in standby battery circuitry.
  8. Failure of battery charging.
  9. Abnormal position of any switch at fire-alarm control unit or annunciator.
  10. Voice signal amplifier failure.
- E. System Supervisory Signal Actions:
1. Identify specific device initiating the event at fire-alarm control unit, **connected network control panels, off-premises network control panels, and remote annunciators.**
  2. After a time delay of **200 seconds**, transmit a trouble or supervisory signal to the remote alarm receiving station.
- 2.4 FIRE-ALARM CONTROL UNIT
- A. General Requirements for Fire-Alarm Control Unit:
1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.

- a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
    - b. Include a real-time clock for time annotation of events on the event recorder and printer.
    - c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
    - d. The FACP shall be listed for connection to a central-station signaling system service.
    - e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.
  2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
  3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.
- B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
1. Annunciator and Display: Liquid-crystal type, **two** line(s) of **80** characters, minimum.
  2. Keypad: Arranged to permit entry and execution of programming, display, and control commands **and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.**
- C. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
1. Pathway Class Designations: NFPA 72, **Class B.**
  2. Pathway Survivability: **Level 0.**
  3. Install no more than **50** addressable devices on each signaling-line circuit.
  4. Serial Interfaces:
    - a. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
    - b. One **USB** port for PC configuration.
    - c. One RS 232 port for VESDA HLI connection.
    - d. One RS 232 port for voice evacuation interface.
- D. Smoke-Alarm Verification:
1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
  2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
  3. Sound general alarm if the alarm is verified.

4. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.
- E. Notification-Appliance Circuit:
1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
  2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
  3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.
- F. Elevator Recall:
1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:
    - a. Elevator lobby detectors except the lobby detector on the designated floor.
    - b. Smoke detector in elevator machine room.
    - c. Smoke detectors in elevator hoistway.
  2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
  3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
    - a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.
- G. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall **be** connected to fire-alarm system.
- H. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.
- I. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to the campus alarm station.
- J. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided **as a special module that is part of fire-alarm control unit.**

1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.
    - a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
    - b. Programmable tone and message sequence selection.
    - c. Standard digitally recorded messages for "Evacuation" and "All Clear."
    - d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire-alarm control unit.
  2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
  3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.
- K. Primary Power: Obtained from dedicated 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, **supervisory signals** shall be powered by 24-V dc source.
1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
  2. Primary power source shall be identified FIRE ALARM SYSTEM with a red and white engraved plastic sign permanently affixed to the face of the switch. Install lock clips on circuit breakers in the "ON" position.
- L. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch for system operation in the event of primary power source failure. Transfer from normal to auxiliary (secondary) power or restoration from auxiliary to normal power shall be automatic and shall not cause transmission of a false alarm.
1. Batteries: Rechargeable, **Sealed, valve-regulated, recombinant lead acid**.
  2. Provide sufficient capacity to operate the complete alarm system in normal, supervisory, or trouble conditions, including audible trouble signal devices, mode for a period of 24 hours. Following this period of operation on battery power, the battery shall have sufficient capacity to operate all components of the system, including all alarm notification devices in alarm mode for a period of 15 minutes.
  3. Locate batteries either within the control panel or in a separate substantial steel cabinet, finished on inside and outside with enamel paint. Provide a non-corrosive base and cylinder lock keyed to match FACP. Separate cells to prevent contact between terminals of adjacent cells and between terminals and other metal parts. If providing separate battery cabinet, identify as FIRE ALARM SYSTEM BATTERY CABINET with a red and white engraved plastic sign permanently affixed to the face of the panel.
  4. Battery Charger: Provide solid state automatic float type, capable of recharging completely discharged batteries to fully charged condition in 24 hours or less.

Locate charger within the control panel or within the battery cabinet. Provide voltmeter and ammeter to indicate battery voltage and charging current.

- M. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

## 2.5 MANUAL FIRE-ALARM BOXES

- A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
  - 1. Double-action mechanism requiring two actions to initiate an alarm, **pull-lever** type; with screw terminals and **integral** addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit. When the station is operated, the handle shall lock in a manner showing visual indication of operation.
  - 2. Station Reset: Key-operated switch. Stations shall be keyed alike with the fire alarm control panel.
  - 3. Manual pull stations that initiate an alarm condition when opening the unit are not acceptable.
  - 4. Indoor Protective Shield: Where indicated on drawings, provide factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
  - 5. Weatherproof Protective Shield: Where indicated on drawings, provide factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

## 2.6 SYSTEM SMOKE DETECTORS

- A. General Requirements for System Smoke Detectors:
  - 1. Comply with UL 268; operating at 24-V dc, nominal.
  - 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
  - 3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
  - 4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
  - 5. Integral Visual-Indicating Light: LED type, indicating detector has operated **and power-on status**.
  - 6. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration,

sensitivity, and alarm condition **and individually adjustable for sensitivity by fire-alarm control unit.**

- a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
- b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).
- c. Multiple levels of detection sensitivity for each sensor.
- d. Sensitivity levels based on time of day.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
  - a. Primary status.
  - b. Device type.
  - c. Present average value.
  - d. Present sensitivity selected.
  - e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
  - a. Primary status.
  - b. Device type.
  - c. Present average value.
  - d. Present sensitivity selected.
  - e. Sensor range (normal, dirty, etc.).
3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

## 2.7 CARBON MONOXIDE DETECTORS

- A. General: Carbon monoxide detector listed for connection to fire-alarm system.
  - 1. Mounting: Adapter plate for outlet box mounting.
  - 2. Testable by introducing test carbon monoxide into the sensing cell.
  - 3. Detector shall provide alarm contacts and trouble contacts.
  - 4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
  - 5. Comply with UL 2075.
  - 6. Locate, mount, and wire according to manufacturer's written instructions.
  - 7. Provide means for addressable connection to fire-alarm system.
  - 8. Test button simulates an alarm condition.

## 2.8 HEAT DETECTORS

- A. General Requirements for Heat Detectors: Comply with UL 521.
  - 1. Temperature sensors shall test for and communicate the sensitivity range of the device.
- B. Heat Detector, Combination Type: Actuated by either a fixed temperature of **135 deg F (57 deg C)** or a rate of rise that exceeds **15 deg F (8 deg C)** per minute unless otherwise indicated.
  - 1. Mounting: **Adapter plate for outlet box mounting Twist-lock base interchangeable with smoke-detector bases.**
  - 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

## 2.9 NOTIFICATION APPLIANCES

- A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.
- B. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.
  - 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
- C. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- high letters on the lens.

1. Rated Light Output: 15/30/75/110/135/185 cd, selectable from the fire alarm control unit or in the field.
2. Mounting: Wall mounted to standard electrical box unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, **red**.

D. Voice/Tone Notification Appliances:

1. Comply with UL 1480.
2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
3. High-Range Units: Rated 2 to 15 W.
4. Low-Range Units: Rated 1 to 2 W.
5. Mounting: **Flush or surface mounted and bidirectional**].
6. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.10 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate. The door portion shall have a plated steel pivot mounted armature with shock absorbing nylon bearing.
1. Electromagnets: Require no more than 1 W to develop 35-lbf holding force.
  2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
  3. Rating: 24-V dc operating on power from the fire alarm control panel.
- B. Material and Finish: Match door hardware.
- C. Operation: Under normal conditions, the magnets shall attract and hold the door open. Upon activation of the building fire alarm system, the devices shall be de-energized, thus releasing the doors on the circuit.

2.11 REMOTE ANNUNCIATOR

- A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
1. Mounting: **Flush** cabinet, NEMA 250, Type 1.
- B. Display Type and Functional Performance: LCD Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to

acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

## 2.12 ADDRESSABLE INTERFACE DEVICE

### A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

### B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

### C. Integral Relay: Capable of providing a direct signal **to elevator controller to initiate elevator recall to circuit-breaker shunt trip for power shutdown.**

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

### D. Control Module:

1. Operate notification devices.
2. Operate solenoids for use in sprinkler service.

## 2.13 NETWORK COMMUNICATIONS

### A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.

### B. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

## 2.14 DEVICE GUARDS

### A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection. Factory fabricated and furnished by device manufacturer with painted finish to match the protected device.

**PART 3 - EXECUTION:**

**3.1 EXAMINATION**

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
  - 1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

**3.2 EQUIPMENT INSTALLATION**

- A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
  - 1. Devices placed in service before all other trades have completed cleanup shall be replaced.
  - 2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.
- B. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.
- C. Manual Fire-Alarm Boxes:
  - 1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
  - 2. Mount manual fire-alarm box on a background of a contrasting color.
  - 3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.
- D. Smoke- or Heat-Detector Spacing:
  - 1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
  - 2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
  - 3. Smooth ceiling spacing shall not exceed **30 feet, unless noted otherwise.**

4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A in NFPA 72.
  5. HVAC: Locate detectors not closer than **36 inches** from air-supply diffuser or return-air opening.
  6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.
- E. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.
- F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.
1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
- G. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in unsprinklered elevator shafts.
- H. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound. Where more than one detector in a suite is in alarm, the system shall all notification devices.
- I. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.
- J. Audible and Visible Alarm-Indicating Devices: Install 80-inches above the floor but not less than 6 inches below the ceiling. Install devices on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.
- K. Door Holders: locate armature 6" down from top and 6" in from strike side of leaf. Where door swing prevents direct contact between armature and holder pole piece, provide plated chain to close gap as tightly as possible. Verify holder positioning with architect prior to mounting any devices.
- L. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- M. Provide wire guards for all devices in areas where prone to physical damage such as gyms. Wire guards shall allow for proper clearance around devices.
- N. Where the anticipated atmosphere or installation conditions require weather-proof, explosion-proof or other specially housed devices, they shall be U.L.-listed and NFPA-compliant and provided as indicated or required. Verify installation conditions and

indicate type of device on shop drawing submission. Provide weather-proof device and backbox.

### 3.3 PATHWAYS AND CONDUCTORS

- A. All fire alarm wiring shall be in conduit. All alarm and signal wiring shall be in accordance with the manufacturer's recommendations and installed in an approved raceway specified in Division 26.
- B. All junction boxes and exposed conduit shall be colored with red enamel paint and manufactured to designate "Fire Alarm".
- C. All surface boxes shall be as manufactured by the device manufacturer for the installed device and shall match devices in size.
- D. The number of wiring splices shall be minimized throughout. Excessive wire splicing shall be cause for rejection of the work, if so determined by the Engineer.
- E. . Appliances shall be wired with UTP conductors, having a minimum of 3 twists per foot.

### 3.4 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.
  - 1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.
- B. Coordinate connections to electronic access-controlled doors with door hardware specifications and actual door hardware. Provide all connections for release of locking mechanisms in egress paths as required.
- C. Verify exact connection requirements to all equipment and devices of other trades with those trades prior to ordering equipment.
- D. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
  - 1. Smoke dampers in air ducts of designated HVAC duct systems.
  - 2. Magnetically held-open doors.
  - 3. Electronically locked doors and access gates.
  - 4. Alarm-initiating connection to elevator recall system and components.
  - 5. Supervisory connections at valve supervisory switches.
  - 6. Supervisory connections at elevator shunt-trip breaker.
  - 7. Data communication circuits for connection to mass notification system.

8. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
9. Supervisory connections at fire-pump engine control panel.

### 3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
- B. Install framed instructions in a location visible from fire-alarm control unit.

### 3.6 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- B. Ground shielded cables at the control panel location only. Insulate shield at device location.

### 3.7 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by owner's representative and **authorities having jurisdiction**. Provide written notice to all concerned parties 72-hours prior to testing.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections. The manufacturer's authorized representative shall provide on-site supervision of installation, and shall perform the initial "power-up" of the system after they have thoroughly checked the installation.
- C. Perform the following tests and inspections **with the assistance of a factory-authorized service representative**:
  1. Visual Inspection: Conduct visual inspection prior to testing.
    - a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    - b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
  2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
  4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
  5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
  6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- E. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- F. Prepare certified test and inspection reports and provide copies to the authorities having jurisdiction, owner's representative, and Engineer.

### 3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.
- B. The Contractor shall provide a minimum of eight hours of instructional time to the Owner in the operation and maintenance of all equipment and components. A receipt shall be obtained from the Owner that this has been accomplished, and a copy included in the close-out documents.
- C. Contractor and manufacturer shall be required to accompany the engineer on a complete system verification after the installation has been certified. This shall include physically testing each device and reviewing descriptive device readout.

### END OF SECTION

**SECTION 27 40 00**

**AUDIO VISUAL SYSTEM**

**PART 1 - GENERAL**

**1.01. DESCRIPTION**

- A. The work required under this section of the specifications consists of the furnishing, installation, and programming of independent audiovisual systems for the Butts County Historical Courthouse. Reference floor plan drawings for audio visual equipment locations. In addition to all audio visual components, the contractor shall be required provide coordination with the data infrastructure systems and cable television systems. Also the contractor shall coordinate with the electrical contractors for all raceway to support the audio visual systems.
- B. The audio visual scope of work will require the contractor to provide a complete, quality operating system which will display, playback, and route computer, video, and audio signals as well as control signals to each noted space of the building. A factory-approved representative shall complete all system connections. A factory approved and factory trained representative of the contractor shall complete all onsite programming of equipment.
- C. The contractor shall provide all labor, materials, equipment, and supervision to install specified systems. The installation, testing, and commissioning of all equipment shall be the full responsibility of the audio visual contractor for this project.

**1.02. QUALITY CRITERIA AND STANDARDS**

- A. All audio visual wiring, devices, and equipment shall comply with applicable UL, NEC, and NEMA code standards. All audio visual equipment shall be UL-listed and labeled.
- B. Audio visual wiring systems shall conform to established trade and industry standards. The following specifications and standards are incorporated into and become a part of this Specification by reference.
  - 1. AES14-1992 (r2004): – AES Standard for Professional Audio Equipment.
  - 2. AES26-2001– AES Recommended Practice for Professional Audio
  - 3. ICEA S-80-576 ICEA Standard for Communications Wire and Cable for Wiring of Premises
  - 4. NFPA 70 National Electric Code
  - 5. UL 50 Enclosures for Electrical Equipment
- C. Installer's Qualifications:
  - 1. Firm with at least 3 years of successful application, installation, and testing experience on specified systems and equipment.

2. The Contractor must show proof of being in the audio visual trade for a minimum of three years and provide three (3) references with contact names and telephone numbers regarding successful completion of audio visual projects of similar scope and size.
3. All supervisors and installers assigned to the installation of this system or any of its components shall have factory certification from each equipment manufacturer that they are qualified to install and test the provided products. Unqualified staff shall not be used for the installation of the equipment, system cables, and associated hardware.
4. All installers assigned to the installation of this system or any of its components shall have a minimum of 3 years of experience in the installation of the specified audio visual equipment and components.
5. All installers assigned to the installation of this System or any of its components shall have a minimum of 3 years' experience in the installation of the specified Audio Visual equipment and components.
6. All Audio Visual Contractor staff assigned to this project shall be full-time employees and having been in the employ of the Audio Visual Contractor for at least 12-months. The proposed use of newly hired staff must be disclosed in advance of any work to the Owner/General Contractor and references and certifications submitted for their approval. No more than 25% of the assigned staff for the project and its components can be newly hired.
7. Audio Visual Contractors are limited in their use of subcontractors to no more than 20% of the assigned staff for the project and its components. In addition, the proposed use of subcontractors must be disclosed in advance of any work to the Owner/General Contractor and references, certifications and insurance submitted for their approval.

#### 1.03. SUBMITTALS

- A. Product Data: Audio Visual contractor shall provide a numbered equipment list of the systems devices he is providing. The list shall include quantity of items, manufactures product number, description of item and audio visual specification that it represents. Submit manufacturer's technical product technical data sheet for each item of systems equipment in order of the numbered equipment list. Submittal shall include drawings that contain complete floor plans and reflected ceiling plans, wiring and schematic diagrams and other details required to demonstrate that the system has been coordinated and will function as a complete system. Drawings shall include vertical riser diagrams, equipment rack details, elevation drawings, connector faceplate details, sizes, and type of all cables and raceway.
- B. Shop Drawings: Include drawings that contain complete floor plans and reflected ceiling plans, wiring and schematic diagrams and other details required to demonstrate that the System has been coordinated and will function as a complete system. Drawings shall include vertical riser diagrams, equipment rack details, elevation drawings, connector faceplate details, sizes, and type of all cables and raceway(s). All System(s) single-line diagram(s) are to have wire "Tags" on all connection points that identify the type of signal and/or cabling and a unique identifying number. System single-line drawings that require more than one sheet to properly show System functionality shall have additional wire "Flags". Wiring Flags shall have the drawing number the signal is going to/from and a unique identifying number. Drawings must be

no smaller than Architectural "C" (18-inch x 24-inch) in size and be legible to the naked eye without magnification.

- C. Test Plan: Contractor shall submit a test plan that defines the tests required to ensure that the system meets technical, operational, and performance specifications, 45 days prior to the proposed test date. The test plan must be approved before the start of any testing. The test plan shall identify the capabilities and functions to be tested, and include detailed instructions for the setup and execution of each test and procedures for evaluation and documentation of the results.

#### 1.04. WARRANTY

- A. All equipment shall be new and shall be under warranty for a period of one (1) year, from the date of acceptance by the owner, against defects in equipment or workmanship. Failed equipment shall be replaced by the contractor at no cost to the owner. Owner's personnel may perform initial trouble investigation but replacement of failed equipment and escalated problem support will be handled by the contractor.
- B. Audio Visual Contractor shall provide at project closeout a service document that shall clearly detail methods of contact for warranty service including issues categorized as "emergency" with turnaround times for return contact, on-site service and up-and-running time frame. If free loaner equipment is included while equipment is out for service or if there are fees for loaner equipment.
- C. Audio Visual Contractor shall also provide details of what constitutes warranty and out of warranty service and a list of rates for out of warranty service.
- D. Audio Visual contractor shall provide the cost of an extended warranty providing the same warranty as the first year for a second year, for years two and three, and years two through five.
- E. Audio Visual Contractor standard service response time shall be as follows: 24-hours from time of first contact for a verbal/electronic response, 48-hours to be on-site performing diagnostics and/or repairs.

#### 1.05. ACCEPTABLE MANUFACTURERS

- A. Reference Part 2 - Products Section of the specification for complete list of acceptable manufacturers.
- B. No substitutions shall be allowed during the bidding phase. The chosen Audio Visual Integrator may, and within reason request an equipment substitution by submitting a Substitution Request to the Architect and Audio Visual Consultant within seven (7) days of being awarded the project. Excessive requests for substitutions may incur a fee to be determined by the Audio Visual Consultant and based on their standard hourly rate.

1.06. RECORD DRAWINGS

- A. At the time of final inspection, provide three (3) sets of complete data on Audio visual System equipment used in this project. This data shall be in bound form and shall include all shop drawings required for this project.
- B. All record drawings shall include "as built" system interconnection diagrams with major components identified and number and type of interconnecting conductors.
- C. Maintenance and operating instructions on all systems.
- D. Certification from system manufacturers that systems are installed in accordance with manufacturer's recommendations and are functioning correctly at the time of final inspection.
- E. As-built drawings to show raceway layout and wiring for all systems.
- F. Corrected point-to-point drawings for all systems with color code to show the actual as-built condition.

1.07. CONTROL SYSTEMS

- A. Audio Visual Contractor is to coordinate with owner their required Control System(s) functionality and Graphic User Interface (GUI) layouts.
- B. Audio Visual Contractor is to provide at least one (1) week in advance of System installation details of Control System functionality and complete, sample GUI pages for owner review and comment.
- C. Audio Visual Contractor shall make necessary adjustments in functionality and the GUI as directed by owner after their initial review.
- D. Audio Visual Contractor shall make appropriate Control System changes as necessary (and within reason) based on owner comments for no additional charge one (1) time after Audio Visual System has been in use for fourteen (14) days.
- E. At Project Closeout Audio Visual Contractor is to provide owner with all Control System programming/codes/files in uncompiled format for their use and ownership including all Control System Passwords.

**PART 2 - PRODUCTS**

1.01. GENERAL MATERIALS REQUIREMENTS

- A. Provide all materials under this section of the specifications. Materials and equipment shall be the manufacturers' latest standard design that has been in satisfactory use for at least 1 year prior to installation. See Part 3 - Execution specification section for additional product requirements.

1.02. FIFTY-FIVE INCH FLAT PANEL DISPLAY SCREEN

- A. The Flat Panel Display shall be mounted as indicated in contract drawings. Audio Visual contractor to coordinate screen mounting requirements with General Contractor. Audio visual contractor to provide mounting hardware as per manufactures recommendation. Contractors to ensure that wall surface will accommodate Display weight and installation requirements. Display to be rated for commercial use.
- B. Flat Panel Display specifications of equipment shall include:
  - 1. Video
    - a. Screen Size: Diagonal length of TV screen 55" class.
    - b. Native Resolution: 3840 x 2160
    - c. Dynamic Contrast Ratio: 1,000,000:1 minimum.
    - d. Aspect Ratio: 16:9.
  - 2. Audio
    - a. Variable line level audio output or variable speaker level audio output.
  - 3. Tuner
    - a. Decodes ATSC/NTSC/QAM signals (off-air/analog/digital).
  - 4. Inputs & Outputs
    - a. Inputs
      - 1) HDMI: two minimum
      - 2) RF Input: F-Connector
    - b. Outputs
      - 1) Audio Output (Mini-Jack): One
  - 5. Control
    - a. Accepts RS-232 control. Control via serial port so that the installation of a remote infrared emitter to the front of the display is not required.
- C. Acceptable manufacturers include: NEC E557Q or comparable Samsung or Sharp.
  - 1. Accessories shall include:
    - a. Appropriate wall mount and associated hardware by manufacturer or third-party manufacturer: Chief Manufacturing, Peerless or Premier.
    - b. Display Mount must be lockable.
    - c. Display mount must be able to lock from the bottom, tilted away from the wall, for servicing of the monitor, without removing from the wall.
    - d. Attachable integral speaker kits for flat panel display. (Reference AV System Diagrams)

1.03. FLAT PANEL DISPLAY WALL MOUNT

- A. The Flat Panel Display shall be wall mounted where indicated in the contract drawings. Audio Visual Contractor to provide mounting hardware and submit design for approval by a Structural Engineer. The wall mount can be used to mount displays from a variety of wall structures. It will mount to wood studs, steel studs, or concrete. It will be UL listed and approved. Assembly and installation will be performed according to the instructions provided by the manufacturer.
- B. Flat Panel Display Wall Mount (Medium sized displays) shall meet the following specifications:
  - 1. Type: Wall mounted, low profile mount for Flat-Panels up to 300 lbs. and in the size range from 50"-65" diagonal.
  - 2. Tilt: Capable of 8-degrees of downward tilt.
  - 3. Rotation and swivel: Not required.
  - 4. Adjustments: Built-in lateral shift and post-installation leveling.
  - 5. Security: Locking barrels.
- C. Acceptable manufacturers include: Chief LTM1U Chief Mtg. or comparable from Peerless-AV.

1.04. DIGITAL SIGNAGE PLAYER

- A. The Contractor shall provide a DIGITAL SIGNAGE Player as a source for the video display system.
- B. Digital Signage Player shall meet the following specifications:
  - 1. Decoder Input: 1 H.264/AVC digital video and AAC audio over IP.
    - a. SD slot for SDHC and SDXC; storage via SDXC (up to 2TB)
    - b. Pull Stream Protocols- RTP/RTCP (RFC 3550), RTSP (RFC 2326), interleaved RTSP (RTP/RTSP), RTP/RTSP tunneled through HTTP
    - c. Push Streams- MPEG-2 TS/UDP (ISO/IEC 13818-1), MPEG-2 TS/RTP (RFC 2250), Direct RTP (RFC 3984)
    - d. Stream Discovery- SAP (RFC 2974), SDP (RFC 4145, RFC 4566)
    - e. Transport- TCP, UDP, RTP, multicast or unicast
    - f. Video Coding- MPEG-4 part 10 (AVC) H.264 BP, MP, HiP to level 4.2 (<40 Mbps over 1 second)
    - g. Image file formats- BMP, JPG, PNG, TIFF up to 1920x1080
    - h. Playlist formats- m3u, m3u8, pls, jspf, xspf
  - 2. Video Output: 1 HDMI.
  - 3. Audio Input: 1 HDMI embedded stereo digital audio, 1 analog audio input, balanced/unbalanced, on 3.5 mm captive screw connector.
  - 4. Audio Output: 1 analog audio output, balanced/unbalanced, on 3.5 mm captive screw connector, 1 HDMI embedded digital output.
  - 5. Control: OSD, USB configuration port, 1 bidirectional RS-232, 3.5 mm captive screw connector, 3-pole.

- C. Acceptable manufacturers include: BrightSign XD1034 or comparable.

1.05. WIRING & CONNECTORS:

- A. All system wiring shall be plenum rated.
- B. Basic speaker cables shall be single twisted pair shielded cables, minimum of 14 gauge, stranded, tinned copper, aluminum-polyester shield, with stranded tinned copper drain wire. Cable shall be UL listed type 246A.
- C. For balance of A/V cables and connectors, reference one-line diagram in contract documents and provide appropriate cables and connectors to ensure a fully functional audio visual system.
- D. UTP cabling shall be at a minimum of CAT6 requirements or as indicated on drawings.

1.06. TRANSIENT VOLTAGE SURGE SUPPRESSION

- A. Transient voltage surge suppression devices shall be provided to protect both power strips in each rack and all equipment in each Lectern. Transient voltage surge suppression shall be provided for all audio visual equipment devices.
- B. Transient voltage surge suppression devices shall be an industrial-grade surge suppressor with EMI/RFI filtering.
- C. Transient voltage surge suppressors shall meet the technical requirements of SurgeX Professional AC Power Products.

**PART 3 - EXECUTION**

1.01. INSTALLATION:

- A. General: System components and appurtenances shall be installed in accordance with NFPA 70, manufacturer's instructions, and as shown. Necessary interconnections, services, and adjustments required for complete and operable audio visual systems shall be provided. Components shall be labeled in accordance with TIA/EIA 606. Penetrations in fire-rated construction shall be fire-stopped. A/V cables shall not be installed in the same raceway with AC power cables. Cables not installed in conduit or wire ways shall be properly secured and neat in appearance and, if installed in plenums or other spaces used for environmental air, shall comply with NFPA 70 requirements for this type of installation.
- B. Equipment Racks and Cabinets
  - 1. Open frame equipment racks shall be bolted to the floor slab. Cable guides shall be bolted or screwed to racks. Racks shall be installed level.
- C. Rack Mounted Equipment

1. Rack mounted equipment shall be securely fastened to racks by means of the manufacturer's recommended fasteners.

1.02. GROUNDING/BONDING:

- A. System should follow the grounding requirements of the National Electrical Code (NEC). Frame of all metal racks should be grounded. Ground EVLP room video integration system racks per manufacturer's recommendation.

1.03. TESTING AND CHECK-OUT

- A. Testing requirements apply to all equipment. Contractor to test each audio visual component as recommended by manufacturer. Test methods and test results shall be submitted to the owner prior to final inspection.
- B. Materials and documentation to be furnished under this specification are subject to inspections and tests. All components shall be terminated prior to testing. Equipment and systems will not be accepted until the required inspections and tests have been made, demonstrating that the audio visual systems conform to the specified requirements, and that the required equipment, systems, and documentation have been provided.

1.04. TRAINING:

- A. The Contractor shall include in the base Contract all costs required to train owners operating and maintenance personnel in the use and maintenance of systems provided under this section of the Specifications. Training sessions shall be conducted by instructors certified in writing by the manufacturer of the specific system.
- B. Sessions shall be conducted for not less than four-hour periods during normal working hours, i.e., Monday through Friday, 8:00 AM to 5:00 PM. Training session schedules shall conform to the requirements of the owner; therefore, such schedules shall be submitted to owner for approval not less than two weeks prior to the training session. All training sessions shall be recorded for future use. At Owner's discretion, provisions shall be made to allow up to two owner personnel to participate in final system check out of all systems.
- C. Recordings shall be of professional quality for both video and audio and must be approved by the Owner/User. Provide two copies to Owner/User. Time to be included in base Contracts for specific systems shall be as follows:

1. Audio Visual Systems- 16 hours

1.05. AS-BUILT DRAWINGS AND/OR DOCUMENTATION:

1. As-built drawings shall be provided noting the exact cable path and cable labeling information. Drawings in .DWG format shall be provided by the contractor. As-builts shall be submitted to the owner on formatted CD's, saved

- as .DXF or .DWG files. Redline hardcopies shall be provided as well. CAD generated as-built information shall be shown on a new layer named AS-BUILT.
2. System Acceptance: Before the owner accepts the system, the contractor shall be required to walk-through the installation with the owner's representative and the design engineer to verify proper installation and operation.

**END OF SECTION**

**SECTION 28 21 00**

**ACCESS CONTROL SYSTEM**

**PART 1 - GENERAL**

**1.01 RELATED DOCUMENTS**

- A. Contract drawings and general provisions of the Contract apply to this section.

**1.02 SUMMARY**

- A. This section of the specifications requires the Security Contractor to provide and install a Card Access Control System herein referred to as the Access Control System (ACS).
- B. The ACS System shall be a distributed system using both conventional LAN network communications as well as direct connect RS485 for information distribution throughout the buildings.
- C. The Security Contractor must supply and install all computer hardware, system software upgrades and licenses to integrate all new devices into the existing Continental access control system.
- D. The Security Contractor will be required to provide card readers and other associated devices at each door, along with the low voltage cable between the door and access control panel locations.
- E. The Security Contractor shall be required to coordinate and include all customized programming for the ACS per the requirements of the OWNER. The contractor shall be responsible for coordinating with the OWNER'S administrative personnel in programming all ACS features and functions. This customization shall include alarm messages, security schedules, etc.
- F. The Security Contractor shall be responsible for all cabling, hardware, and miscellaneous equipment necessary for a fully functional system.
- G. The Security Contractor shall provide all labor, materials, equipment and supervision to install, check out, adjust, and calibrate the total system.
- H. All electric door hardware is being provided and installed by the General Contractor (GC). The security contractor shall connect, power, and program all door hardware installed by the General Contractor. All door position switches shall be provided and installed by the security contractor. Power supply units for powering high current electrified exit devices shall be provided and installed by the General contractor. Power supply units for all other type electrified locks shall be provided and installed by the security contractor.

1.03 ACCEPTABLE MANUFACTURERS FOR THE ACS

- A. Reference Part 2 of this specification.

1.04 QUALITY ASSURANCE

- A. Industry Referenced Standards. The following specifications and standards are incorporated into and become a part of this Specification by reference.
  - 1. FCC compliance
  - 2. UL compliance
  - 3. NEC compliance

1.05 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including specifications and installation instructions, for each type of system equipment. Include drawings, which contain complete wiring and schematic diagrams and other details required to demonstrate that the system has been coordinated, and will function properly as a system. Drawings shall include floor plan layouts of devices, components, vertical riser diagrams, equipment rack details, elevation drawings of equipment racks, sizes and types of all cables and conduits.
- B. Test Plan: Contractor shall submit a test plan that defines the tests required to ensure that the system meets technical, operational, and performance specifications, 15 days prior to the proposed test date. Owner/User must approve the test plan before the start of any testing. The test plan shall identify the capabilities and functions to be tested, and include detailed instructions for the setup and execution of each test and procedure for evaluation and documentation of the results.
- C. Manufacturer Certification: Submit a letter from the manufacturer's representative stating the proposed system being submitted for review are in accordance with the recommendations of the manufacturer.
- D. It is the responsibility of the contractor to meet with the appropriate OWNER'S Representatives to compare the placement and installation of proper devices with the drawings and specifications. A 100% device by device test will be conducted by the vendor under the supervision of the owner's representative. Punch lists will be developed at that time and furnished to the contractor. All punch list items must be corrected and verified prior to acceptance of the system.

1.06 DRAWINGS

- A. The Contract Drawings indicate the arrangement of the access control system equipment. Coordinate installation of equipment with the structural, mechanical, and electrical equipment and access thereto. Coordinate installation of recessed equipment with concealed ductwork and piping, and wall thickness.
- B. All raceways required for the ACS System are not shown on the Contract Drawings.

#### 1.07 RECORD DOCUMENTS

- A. At the time of final inspection, provide three (4) sets of complete data on the ACS used in this project. This data shall be in bound, hard copy form and shall include all shop drawings required for this project. One (1) CD with complete data and drawings must also be provided. This complete data shall include the following.
  - 1. Warranty Statement (include warranty start date, service provider contact phone number and address)
  - 2. Letters of certification from system manufacturers
  - 3. Maintenance and operating instructions on all systems
  - 4. As-built drawings for all systems with color code to show the actual as-built conditions
- B. All record drawings shall include "as built" system interconnection diagrams with major components identified and number and type of interconnecting conductors. Drawings must be submitted as full-size, bound sets as well as electronic files on CD.
- C. Three ring binders with maintenance and operating instructions on all systems. These binders must incorporate a cover with project name, an index and sections for each major component. A total of four (4) binders will be required.
- D. Certification from system manufacturers that systems are installed in accordance with manufacturer's recommendations and are functioning correctly at the time of final inspection.
- E. As-built drawings to show conduit layout and wiring for all systems.
- F. Point-to-point drawings for all systems with color code to show the actual as-built conditions. Copies of the contract document drawings, without modifications showing actual as-built conditions will not be accepted.
- G. All as-built information shall be submitted as hard copy and in electronic format. Drawings shall be AutoCAD 2015 "DWG" files.

#### 1.08 WARRANTY

- A. The contractor shall warrant the ACS for one (1) year from date of receiving substantial completion from the Owner/User against defects in equipment or workmanship. Failed equipment shall be replaced by the contractor at no cost to the owner. Owner's personnel may perform initial trouble investigation but replacement of failed equipment and escalated problem support will be handled by the contractor.
- B. Provide spare parts in accordance with SCO requirements/percentage based.

#### 1.09 DESCRIPTION

- A. The work included under this section of the specifications consists of the installation of a complete ACS. Provide all labor, equipment, materials, and

supervision to install, calibrate, adjust, document, and test the total system as required herein and on the drawings.

- B. The contractor shall provide all documentation and shall perform all duties involved in obtaining work permits as required to complete the project. All permitting shall be within the associated city or jurisdiction.
- C. The work shall consist of the installation of a complete ACS consisting essentially of, but not limited to, the following major components:
  - 1. Upgrading existing Security Server (computer hardware and software)
  - 2. Intelligent System Controller
  - 3. Remote Reader Electronics
  - 4. Field Peripheral devices (i.e. card readers/keypad, etc.)
  - 5. Access Control System application software upgrades / licenses
  - 6. Recessed and / or surface mounted door position sensors
  - 7. Emergency phone system
- D. The new ACS shall be integrated with the existing ACS, based upon the standard products of ACS manufacturers, installed within multiple areas of the site using conventional WAN/LAN network and telephone line communication for information distribution.
- E. The project requires the supply and installation of a combined Intrusion Detection, Access Control System, and Emergency phone System. See one-line diagrams in contract documents. The ACS shall include door position status, glass break detectors, and infrared motion detectors for alarm detection functions. The ACS shall perform all door control function for specific doors within the site by routing power to the electric or pneumatic strikes, magnetic locks, and other electrified hardware devices. The ACS shall also monitor the door position status of specific doors as indicated in this specification and shown on the contract drawings.

#### 1.10 SYSTEM OVERVIEW

- A. The ACS shall share a computer with the video surveillance system. The computer shall utilize LAN infrastructure for communication to the remote panel locations. RS 485 communications shall be used from the Reader Interface Panels to other remote access control panel locations.
- B. The ACS shall provide all software functionality as described within these specifications.
- C. The ACS shall be modular, configured in a network, and capable of handling a facility-wide configuration consisting of multiple remote reader interface units. The ACS shall allow for easy expansion or modification of inputs, outputs, operations, and functions. The ACS software shall be under a single software program control, shall provide full integration of all access control system components, and shall be alterable at any time (password protected), depending upon the facility requirements. Reconfiguration shall be accomplished on-line through system programming, without hardware changes.

- D. The ACS shall provide controlled access through designated doors, by utilization of magnetic stripe card readers. The ACS shall utilize a single, seamlessly integrated database for both its telephone entry and access control functions. This integration shall be provided within one operating environment.
- E. The ACS Server shall be able to connect to and monitor field hardware devices, such as card readers, alarm inputs, etc. Also, the ACS Server shall handle tasks such as defining access privileges, time zones, generating reports, etc. (password protected).
- F. The ACS shall provide access control. The system shall be able to make (access granted or denied) decisions for door unlocking control functions, define access levels, and set time zones and holidays, etc. An input/output linkage feature will allow linking of monitor zone points to output control points. The ACS System shall support such features as: Minimum 10,000 cards/key codes capacity, transaction storage capability, 16 access levels, I/O point control, elevator control, and time zone/holiday overrides, etc.
- G. The ACS shall be used for alarm monitoring. The alarm-monitoring screen shall provide information about the time and location of the alarm(s). All alarm points shall be logged, stored, and displayed by the ACS system.
- H. System administrative tasks such as defining system operator permissions, access groups, time zones, reports, maps, etc. shall be provided from Security Server (password protected). Initial setup of the cardholder screen layout shall occur on the database server. The contractor shall be responsible for the creation of these activities for the initial installation of the ACS. Additionally, the contractor shall be responsible for the initial employee/cardholder database creation.

#### 1.11 SYSTEM APPLICATION AND REQUIREMENTS

- A. The ACS shall support a user friendly; Windows style Graphical User Interface (GUI) that shall be intuitive to operate. All messages and interface text shall be in English prose. All functions shall be either keyboard or mouse driven to allow the system operators to choose the method of navigating through the screens.
- B. The ACS shall provide a flashing colored icon annunciation system for each alarm in the system. The ACS shall also support and provide customizable instructions so that each alarm or event in the system can have a text set of instructions.

#### 1.12 NETWORK CONFIGURATION

- A. The system shall be designed to allow it to work with any industry standard network protocol and topology listed below:
  - 1. TCP/IP
- B. Any alarm in the system, regardless of the field control panel that generated the alarm, must be routed to the Security Server.

### 1.13 USER INTERFACE

- A. The ACS shall have an easy to use Windows Graphical User Interface (GUI). It shall be intuitive and all messages and commands shall be in English Prose. All functions shall be both keyboard and mouse driven.
- B. A Help icon shall be available in all modules of the software giving system operators/ system administrators the ability to obtain operating instructions while running the ACS software.

## PART 2 - PRODUCTS

### 2.01 MAGNETIC STRIPE CARD READERS

- A. Contractor to provide and install card readers.
- B. Contractor must coordinate card reader color and finish with the OWNER prior to ordering equipment.
- C. The card reader must incorporate the following:
  - 1. Powered by +5 VDC or +12 VDC, low voltage power.
  - 2. Allow for bidirectional card swipe
  - 3. Two single color LEDs for reader status
  - 4. Audible indicator beeper contacts
  - 5. Dip switch selectable data outputs
  - 6. Optional tamper switch
  - 7. UL 294 Listed, CE marked

### 2.02 CARDS

- A. All access control cards shall be provided by the OWNER.

### 2.03 CENTRAL SYSTEM

- A. The ACS's Central System is an existing:
  - 1. The Contractor must survey the existing server and determine if the existing server is license for the number of readers and workstations required for this project. Should it be determined that a hardware, software or license upgrade is required, the Contractor must include all hardware, software and license upgrades in the base bid.

### 2.04 CARD READER INTERFACE PANEL

- A. Provide and install the additional reader interface panels, system controllers and power supplies necessary to connect the field devices as shown on the contract drawings.
- B. The card reader interface units are shown on the drawings for reference purposes only. The READER INTERFACE PANEL shall be the microprocessor based interface device between the card readers and the ACS Central System.

The READER INTERFACE PANEL shall be compatible with the readers and Central System equipment specified herein. READER INTERFACE PANEL shall be mounted in metal enclosure with ample space to accommodate equipment necessary for amount of readers specified and for 20% future growth. Metal enclosure may also house power supply for door hardware, where specified.

## 2.05 ELECTRIC DOOR HARDWARE

- A. Electric door hardware shall be provided and installed by the General Contractor. The Security Contractor must provide centralized 12 / 24 VDC power supplies for all electrified door locks except for electrified panic devices (provided and installed by General Contractor). Security contractor shall wire, terminate and integrate with fire alarm interface at the access control panel locations.
- B. All electrified door hardware must be interfaced with the fire alarm such that doors automatically unlock in the event of a fire alarm. This shall be the responsibility of the Security Contractor at specified doors controlled by the ACS.

## 2.06 DOOR POSITION SWITCH CONTACTS

- A. Provide magnetic contacts where shown on the contract drawings. All door contacts shall be UL Listed.
- B. Surface mounted door contacts shall be provided with total encapsulation to protect against moisture. Door contact shall have anodized aluminum finish, with an armored stainless steel flexible cable. Contractor to furnish and install Sentrol 2500 series or approved equal.
- C. Door contacts for surface mount roll-up door locations shall rated for harsh, commercial environments. Contact must be provided with total encapsulation to protect against moisture. Door contact shall have anodized aluminum finish, with armored, stainless steel flexible cable. Contractor to furnish and install Sentrol 2200 series or approved equal.
- D. Door contacts for recessed mounted swing or sliding door locations shall be Sentrol 1078 or equal.
- E. Door contacts mounted in locations, other than those shown in the Contract Drawing Details (hinged side of door, surface mounted when Details require recessed, etc.), will not be allowed.

## 2.07 DOOR ALARM SOUNDER

- A. Provide and install alarm sounders at locations shown on the contract drawings. The following are requirements for the alarm sounders:
  - 1. Door alarm shall be a double gang wall mounted device with tri-state LED indicator to show status. Green is bypass, amber when door is authorized to be open, red for warning and alarm condition.
  - 2. Door alarm must provide audible alert tone at a minimum of 20 db. Alert must activate when door is opened. Door alarm must be configurable to

- allow for the alert to automatically reset whenever door is closed or remain active until device is reset from security monitoring center.
3. Door alarm shall be controlled from an output of the access control system to allow software functionality control.

## 2.08 D.C. POWER SUPPLY

- A. Provide low voltage power supply units associated with Local Interface Units and Door Control Panels and as required to provide 24 volt regulated, filtered D.C. power for locking controls, D.C. locks and signal devices. Output power shall be 12 / 24 volt D.C. with ampere rating not less than 150% of load imposed on power supply under most severe conditions of load. D.C. output shall be fused. Output voltage shall be regulated within plus or minus 5% from no load to full load. Power supply shall be UL listed. Power supplies must be equipped with battery back-up.

## 2.09 SYSTEM WIRING

- A. Card reader connection cable shall be of a type specified by the manufacturer of the ACS System. Cable must meet minimum NEC requirements for Class 2 wiring.
- B. Power wiring for electrified door hardware shall not be smaller than No. 18 THWN or XHHW.
- C. All wiring systems shall use solid copper conductors except where flexibility is required.
- D. Stranded conductors shall be acceptable only where all terminations can be made to crimp type screw lug.
- E. All wiring systems shall be color-coded so that each conductor for individual lockset is of a distinctive color. All wiring shall be in accordance with the manufacturers written recommendations. All cabling/wiring shall be submitted in a detailed spreadsheet including cut sheets and samples to the Owner prior to any installation.
- F. All conductors within junction boxes, pull boxes, and equipment cabinets shall be grouped and laced with nylon tie straps with identification tab, for individual locksets.

## 2.10 DOOR CONTROL PANEL

- A. The DOOR CONTROL PANEL (DCP) shall operate and control access to multiple doors as a total standalone unit with distributed database and no dependency on the Central System. All valid card numbers, time zones, relay pulse times, and alarm point shunt times shall be loaded into the controller's memory. The multiple reader/keypad access control panel shall support Wiegand, magnetic stripe, proximity, keypads, barcode, vehicle ID, barium ferrite and biometric devices.

## 2.11 REQUEST TO EXIT

- A. Provide request to exit (REX) push button or passive infrared devices where shown on the Contract Drawings.
- B. Mount wall push button type (REX) devices at 48 inches AFF. Coordinate exact mounting location with other wall mounted devices and equipment. Wall mounted (REX) devices shall be single-gang aluminum faceplate with heavy duty mushroom head type pushbutton. Pushbutton contacts shall have minimum contact ratings of 24 VDC/2 Amps, 120 VAC 60 Hz./5 Amps. (REX) shall have permanent text labeling to read "PUSH TO EXIT". (REX) shall fit standard single-gang electrical backbox and shall be secured to backbox using tamperproof type screws. Termination of (REX) device wiring may be by screw terminal or pigtail wiring using proper crimp type connectors. (REX) devices shall be connected to the ACS System READER INTERFACE PANEL's and/or DCU's to effect automatic unlocking of electric door operators and locks. Submit (REX) devices for approval before installation of device.
- C. Wall mount passive infrared motion detectors (PIR), used as (REX) devices, to effect automatic unlocking of electric door operators and locks via ACS System's READER INTERFACE PANEL's and/or DCP's. (PIR) devices shall have wide angle, long range lenses (adjustable) to detect motion of personnel desiring to exit through the door. Coordinate exact field mounting location to provide best operation of (PIR) type (REX) device. (PIR) device shall operate at 9.0 to 16.0 VDC and have form-C output contacts rated at minimum 24 VDC/0.5 amps.
- D. Approved manufacture shall be Bosch or approved equal.

## 2.12 UNINTERRUPTIBLE POWER SUPPLY (UPS)

- A. Provide and install an uninterruptible power supply (UPS) at the location of the Security Workstation. UPS system to provide battery backup for a minimum of one (1) hour.
- B. The UPS shall be an on-line double conversion UPS which shall have the following minimum features:
  - 1. Audible Alarms
  - 2. Automatic Self Test
  - 3. Automatic Voltage Regulation (AVR)
  - 4. Building wiring fault indicator
  - 5. Hot Swap Batteries with Intelligent Battery Management
  - 6. Lightning and Surge Protection
  - 7. Line-interactive
  - 8. Load Meter
  - 9. Network-grade line conditioning
  - 10. Overload Indicator
  - 11. Rack Mount
  - 12. Replace Battery Indicator
  - 13. Sine-wave output
  - 14. Status Indicator LED's
  - 15. UPS shall have the ability to handle crest factor ratios of 2.5 or above.

16. UPS shall provide continuous (no-break power) during momentary or complete blackouts.
  17. UPS shall have the ability to recharge the battery to 90 percent capacity within a reasonable period of time (5 to 10 times the discharge time).
  18. The UPS output shall be regulated with maximum deviations from nominal of +6 percent to -13 percent over the full input range, both AC and DC.
  19. UPS shall meet ANSI C84.1 requirements.
- C. UPS and batteries shall be sized to 150% output of the required load of head end equipment. Furnish load calculations with shop drawings verifying UPS sizing in compliance with these specifications.
- D. Batteries shall be valve regulated (sealed or maintenance free) lead-acid cell type. Batteries shall be installed within the UPS enclosure or in a standard enclosure provided for that purpose by the UPS manufacturer.
- E. Electrical Contractor shall provide 120 VAC / 20 AMP power circuits at Access Control Panel and Video Surveillance equipment locations.
- F. Approved manufacturer shall be APC, Tripp Lite, Falcon or approved equal.

#### 2.13 TRANSIENT VOLTAGE SURGE SUPPRESSION

- A. Protect all equipment against surges induced on all video, and power cables. All copper cables and conductors which serve as 120V power, control, or video conductors shall have surge protection circuits installed at each end and locations where conductors enter or exit a building. Fuses shall not be used for surge protection.
- B. Surge suppression devices shall meet the following standards/publications:
1. UL 497B
  2. UL 1449 (must meet 330 Volt suppression rating)
  3. IEEE Category B impulse and ring wave tests
- C. Acceptable Manufacturers: Northern Technologies, Inc., EDCO. Product shall be warranted against defect for a period of not less than five (5) years.
- D. All power connections, including 24 VDC and 24 VAC power supplies and direct wired or plug-in 120 VAC power connections, for all systems and components specified herein, shall be equipped with surge suppression devices. Devices shall be bonded to building grounding system in accordance with Article 250 of the National Electric Code.
- E. Grounding: Provide a dedicated, separate No. 6 AWG copper conductor from building grounding system to all security equipment rooms, security equipment cabinets, and control rooms. Connect all lightning protection devices and security equipment non-current carrying metal parts to grounding conductor in accordance with Article 250 of the National Electric Code. Provide ground bus bar in each equipment room and control room with dedicated ground conductor to each cabinet, enclosure, pull/junction box and all equipment.

- F. Ground Resistance Measurement: Each signal ground system D.C. resistance shall be measured between any point on the signal ground bus and the earth ground. An instrument designed specifically to measure the resistance of a point to each earth ground shall be used. The systems subcontractor shall measure ground resistance in accordance with the procedure as outlined by the test equipment manufacturer. Instrument shall be Biddle earth resistance test instrument or approved equal.

## **PART 3 - EXECUTION**

### **3.01 SEQUENCE OF OPERATIONS**

- A. The Security Server shall operate as an alarm monitoring/controlling workstation. The Security Server shall be able to connect to and monitor and control field hardware devices, such as card readers, etc.
- B. The ACS shall be provided with an interface with the Fire Alarm System to effect automatic unlocking of specified doors controlled by the ACS System during fire alarm conditions. It is the responsibility of the Security Contractor to ensure that the ACS is properly interfaced with the Fire Alarm System for emergency release of specified doors controlled by the ACS system.

### **3.02 WIRING SYSTEMS**

- A. Protect all communication and data equipment against surge induced on all control, sensor and data cables. All cables and conductors which serve as control, sensor, or data conductors shall have surge protection circuits installed at each end that meet the IEEE 472 surge withstand capability test and the electrical transient tests established in UL365. Fuses shall not be used for surge protection.
- B. The work under this section of the specifications includes the installation of all wiring for the electrified door hardware. The actual connections to the electrified hardware and the access control system shall be done under this section of the specifications. It is the responsibility of the Security Contractor to coordinate all electrical requirements and connections of the electrified hardware.

### **3.03 CARD READER AND DOOR CONTROL PANELS**

- A. Mount card reader sensors at a height of 42" AFF to center, unless shown otherwise. Mount card readers securely to the mounting surfaces and provide weather caulking around exterior mounted readers.
- B. Mount door control panels where shown on the contract drawings or where required to provide a completely operational system.

### **3.04 TESTING**

- A. Testing requirements apply to all new construction.

- B. Materials and documentation to be furnished under this specification are subject to inspections and tests. All components shall be terminated prior to testing. Equipment and systems will not be accepted until the required inspections and tests have been made, demonstrating that the access control system conforms to the specified requirements, and that the required equipment, systems, and documentation have been provided.

### 3.05 TRAINING

- A. The Contractor shall include in the base Contract all costs required to train operating and maintenance personnel in the use and maintenance of systems provided under this section of the Specifications. Training sessions shall be conducted on site and by instructors that are certified in writing by the manufacturer of the specific system.
- B. Training session requirements shall include two (2) - four hour sessions with an additional 8 hours provided after the owner accepts the system. Up to two (2) sessions may be held on the same day. Training session schedules shall conform to the requirements of the OWNER; therefore such schedules shall be submitted to the owner for approval not less than two weeks prior to the training session.
- C. All training sessions shall be video-taped for future use. Contractor must provide two copies of the training tapes in DVD format with the project close out documents.
- D. The Contractor shall initially provide 8 hours of training. Then provide an additional 8 hours of training 30 days after OWNER accepts the system.
- E. Time to be included in base Contracts for specific systems shall be as follows:
  - 1. ACS System entirely - 16 hours

### END OF SECTION

**SECTION 28 23 00**

**IP VIDEO SURVEILLANCE SYSTEM**

**PART 1 – GENERAL**

**1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

**1.02 SUMMARY**

- A. This section includes furnishing and installing all materials and providing all labor and supervision pertaining to the supply/installation and integration of IP cameras with the existing IP Video Surveillance System for the project. The Security Contractor is to provide high-resolution color Megapixel cameras for all interior locations and high-resolution Megapixel color DAY / NIGHT WDR cameras for exterior locations. Reference floor plans and camera schedule for camera type and locations. The Security Contractor shall supply and install Network Video Recorders (NVR). All cameras shall be connected to and be recorded by the NVRs. The NVR's shall be located in the building main telecom room and record video for all new IP cameras. The video surveillance system contractor shall be responsible for all cabling, hardware, and miscellaneous equipment required to provide a fully functional system. The video surveillance contractor shall provide all labor, materials, equipment and supervision to install, check out, adjust, and calibrate the total system.
- B. The security contractor shall coordinate with Campus IT for provided PoE network ports for each camera.
- C. The Security Contractor shall be responsible for connecting the required network video recorder and all cameras to the owner provided Local Area Network (LAN) for connection to the existing VMS server and video workstations. Contractor is responsible for providing the necessary computer hardware and associated software upgrades, including all video channel licenses required to integrate the new cameras into the existing video system. All cameras provided shall be 100% compatible with the existing VMS. Reference contract drawings for complete requirements.
- D. This division of the Specifications covers the complete IP video surveillance system as indicated on the Drawings and specified herein. The contractor shall

provide all labor, materials, equipment, and supervision to install the specified system. The installation of all equipment and raceways shall be the full responsibility of the video surveillance contractor for this project.

- E. All conflicts between the drawings and specifications shall be brought to the attention of the owner as soon as possible. In general, specification requirements shall take precedence over drawing requirements.

#### 1.03 QUALITY ASSURANCE

- A. Industry Referenced Standards. The following specifications and standards are incorporated into and become a part of this Specification by reference.
  - 1. NFPA 70 National Electric Code
  - 2. UL 50 Enclosures for Electrical Equipment

#### 1.04 INSTALLER'S QUALIFICATIONS:

- A. Firm with at least 5 years of successful application, installation, and testing experience on specified systems and equipment. All supervisors and installers assigned to the installation of this system or any of its components shall have factory certification from each equipment manufacturer that they are qualified to install and test the provided products. General electric trade staff shall not be used for the installation of the video surveillance system and associated hardware. All installers assigned to the installation of this system or any of its components shall have a minimum of 3 year's experience in the installation of the specified equipment.
- B. The responsibilities of the video surveillance contractor shall include but not be limited to the following:
  - 1. Shop drawings on all video surveillance systems and equipment.
  - 2. Installation of all new video surveillance systems and equipment as documented in the drawings and specifications.
  - 3. Wire and wiring termination for all video surveillance and control systems and equipment.
  - 4. Testing and check-out of all video surveillance systems and equipment.
  - 5. Training for all video surveillance systems and equipment.
  - 6. Warranty for all video surveillance systems and equipment.
  - 7. As-Built drawings, operations and maintenance for the complete video surveillance system.

#### 1.05 RELATED DOCUMENTS

- A. Contract drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section and shall be considered a part of this section and shall have the same force as if specified herein full.

#### 1.06 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data, including specifications and installation instructions, for each type of system equipment. Include drawings that contain complete wiring and schematic diagrams and other details required to demonstrate that the system has been coordinated and will function properly as a system. Drawings shall include floor plan layouts showing device locations, vertical riser diagrams, equipment rack details, elevation drawings of equipment racks, sizes and type of all cables and conduits.
- B. Test Plan: Contractor shall submit a test plan that defines the tests required to ensure that the system meets technical, operational, and performance specifications, 30 days prior to the proposed test date. The test plan must be approved before the start of any testing. The test plan shall identify the capabilities and functions to be tested, and include detailed instructions for the setup and execution of each test and procedures for evaluation and documentation of the results.
- C. Manufacturer Certification: Submit a letter from the manufacturer's representative stating the proposed systems being submitted for review are in accordance with the recommendations of the manufacturer.
- D. It is the responsibility of the contractor to meet with the appropriate owner representative to compare the placement and installation of proper devices with the drawings and specifications. The contractor under the supervision of J & A Engineering and the owner staff will conduct a complete device-by-device test. Punch lists will be developed at that time by the owner representative and furnished to the contractor. All punch list items must be corrected and verified prior to acceptance of the system.

#### 1.07 DRAWINGS

- A. The Drawings indicate the arrangement of security and video surveillance equipment. Coordinate installation of equipment with the structural, mechanical and electrical equipment and access thereto.
- B. Raceway home runs as shown on the security and video surveillance Drawings shall be installed as shown on the Drawings, and as required by the associated equipment manufacturers.

## 1.08 RECORD DOCUMENTS

- A. At the time of final inspection, provide three (3) sets of complete data on security and video surveillance equipment used in this project. This data shall be in bound, hard copy form and shall include all shop drawings required for this project. One (1) CD with complete data and drawings must also be provided. This complete data shall include the following.
  - 1. Warranty statement (include warranty start date, service provider contact phone number and address)
  - 2. Letters of certification from system manufacturers
  - 3. Maintenance and operating instructions on all systems
  - 4. As-built drawings for all systems with color code to show the actual as-built conditions.
- B. All record drawings shall include "as built" system interconnection diagrams with major components identified, along with number and type of interconnecting conductors. Drawings must be submitted as full-size, bound sets as well as electronic files on CD.
- C. Binders with maintenance and operating instructions on all systems. These binders must incorporate a cover with project name, an index and sections for each major component. A total of four (4) binders will be required.
- D. Certification from system manufacturers that systems are installed in accordance with manufacturer's recommendations and are functioning correctly at the time of final inspection.
- E. As-built drawings to show wiring for all installed equipment.
- F. Point-to-point drawings for all systems with color code to show the actual as-built conditions. Copies of the contract document drawings, without modifications showing actual as-built conditions will not be accepted.
- G. All as-built information shall be submitted as hard copy and in electronic format. Drawings shall be AutoCAD 2015 "DWG" files.

## 1.09 ACCEPTABLE MANUFACTURERS

- A. Reference products section of specifications for acceptable manufacturers.

## 1.10 WARRANTY

- A. The contractor shall warrant the video surveillance system for one year from date of start-up against defects in equipment or workmanship. Failed equipment shall be replaced by the contractor at no cost to the owner. Owner's personnel may perform initial trouble investigation but replacement of failed equipment and escalated problem support will be handled by the contractor.

## **PART 2 – PRODUCTS**

### **2.01 MATERIALS**

- A. Materials or equipment specified by manufacturer's name shall be provided, unless approval of other manufacturers is listed in addendum to these Specifications. Any materials or equipment approved in addendum shall function the same as the equipment specified.
  - 1. The approved camera manufacturers are Axis or approved equal.

### **2.02 EXTERIOR DAY/NIGHT FIXED DOME IP CAMERAS (5 MP)**

- A. The camera shall be a progressive scan RGB CMOS 1/4", day/night color CCD camera. Camera shall incorporate Wide Dynamic Range (WDR) technology. Camera shall use automatic digital adjustment control to set color. Camera shall be equipped with an auto infrared cut filter that provides color images during the day and high quality, high sensitivity black-and-white images at night. The camera shall also be equipped with a variable high-speed shutter that compensates for conditions ranging from bright sunlight to low light environments. Camera shall be capable of producing an image up to at least 5 Megapixels. The camera shall also meet or exceed the following minimum requirements:
  - 1. Color Sensitivity: A full video signal shall be produced with a minimum scene illumination of .24 lux, F1.3.
  - 2. B/W Sensitivity: A full video signal shall be produced with a minimum scene illumination of .03 lux, F1.3.
  - 3. Power: POE.
  - 4. Frame rate of 30fps in all resolutions, and in both H.264 and Motion JPEG.
  - 5. Minimum environmental operating conditions shall be -40F to 122F, humidity 5-100% RH (condensing).
  - 6. The camera shall support IPv4/v6, HTTP, HTTPS, QoS Layer 3 DiffServ, FTP, SMTP, Bonjour, UPnP, SNMPv1/v2c/v3, DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP and SOCKS protocols.

7. Dome style housings must be impact resistant and IP66 and NEMA 4x rated casing with integrated dehumidifying membrane. Camera housing shall be provided with tamper resistant fasteners.

B. Acceptable manufacturers for Cameras shall include BOSCH.

## 2.03 INTERIOR FIXED DOME IP CAMERAS (5 MP)

A. The camera shall be a progressive scan RGB CMOS 1/4", day/night color CCD camera. Camera shall incorporate Wide Dynamic Range (WDR) technology. Camera shall use automatic digital adjustment control to set color. Camera shall be equipped with an auto infrared cut filter that provides color images during the day and high quality, high sensitivity black-and-white images at night. The camera shall also be equipped with a variable high-speed shutter that compensates for conditions ranging from bright sunlight to low light environments. Camera shall be capable of producing an image up to at least 3 Megapixels, where indicated on the drawings. The camera shall also meet or exceed the following minimum requirements:

1. Color Sensitivity: A full video signal shall be produced with a minimum scene illumination of .2 lux, F1.3.
2. B/W Sensitivity: A full video signal shall be produced with a minimum scene illumination of .04 lux, F1.3.
3. Power: POE.
4. Shutter speed shall be from 1/20000s to 1/4s.
5. Frame rate of 30fps in all resolutions, and in both H.264 and Motion JPEG.
6. Minimum environmental operating conditions shall be 32F to 122F, humidity 20-80% RH (non-condensing).
7. The camera shall support IPv4/v6, HTTP, HTTPS, QoS Layer 3 DiffServ, FTP, SMPT, Bonjour, UPnP, SNMPv1/v2c/v3, DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP and SOCKS protocols.
8. Dome style housings must be vandal resistant rated casing. Camera housing shall be provided with tamper resistant fasteners.

B. Acceptable manufacturers for Cameras shall include BOSCH.

## 2.04 INTERIOR 360/180 DEGREE PANORAMIC CAMERAS (12 MP)

A. The camera shall be a progressive scan RGB CMOS 1/2.3" day/night color camera. Camera shall incorporate Wide Dynamic Range (WDR) technology. Camera shall use automatic digital adjustment control to set color. Camera shall be equipped with an auto infrared cut filter that provides color images during the day and high quality, high sensitivity black-and-white images at night. The

camera shall also be equipped with a variable high-speed shutter that compensates for conditions ranging from bright sunlight to low light environments. Camera shall be capable of producing an image up to at least 3 Megapixels, where indicated on the drawings. The camera shall also meet or exceed the following minimum requirements:

1. Color Sensitivity: A full video signal shall be produced with a minimum scene illumination of .55 lux
  2. B/W Sensitivity: A full video signal shall be produced with a minimum scene illumination of .18 lux
  3. Power: POE.
  4. Frame rate of 30fps in all resolutions, and in both H.264 and Motion JPEG.
  5. Minimum environmental operating conditions shall be -4F to 104F, humidity 20-93% RH (non-condensing).
  6. The camera shall support IPv4/v6, HTTP, HTTPS, QoS Layer 3 DiffServ, FTP, SMTP, Bonjour, UPnP, SNMPv1/v2c/v3, DNS, DynDNS, NTP, RTSP, RTP, TCP, UDP, IGMP, RTCP, ICMP, DHCP, ARP and SOCKS protocols.
  7. Dome style housings must be vandal resistant rated casing. Camera housing shall be provided with tamper resistant fasteners.
- B. Acceptable manufacturers for Cameras shall include BOSCH.

## 2.05 CAMERA LENSES

- A. Camera lenses shall be compatible with the camera construction and iris control circuit. The lenses shall be compatible with remote control devices as specified herein. The lenses shall be supplied by the same camera manufacturer.
- B. All lenses shall be auto iris type driven by the camera iris control circuit. Additionally, all exterior lenses shall be equipped with spot filters giving the lens a minimum effective aperture of f/360.
- C. Lens size shall be as indicated on the drawings and video surveillance schedule.
- D. Acceptable manufacturers shall include Axis or approved equal.

## 2.06 CAMERA HOUSINGS AND SUPPORTS FOR FIXED CAMERAS

- A. All camera housings and support brackets shall be compatible with CCTV camera specified herein. Housings shall be provided with cable entrance facilities for camera control and power and shall be adaptable to mounting devices used with cameras. All mounts shall be "Feed Through" type to ensure

that power, signal, and data cables are concealed. All camera housings and support brackets shall be securely attached to mounting surfaces. Escutcheon plates attached with security screws shall be used to conceal holes in walls or ceilings. Manufacturer guidelines for mounting devices and support brackets shall be adhered with unless contract details exceed manufacturer guidelines.

- B. Exterior Housing: Housings shall be medium-sized, environmental housings designed for wall and /or ceiling mount applications. Housings mounted on walls or columns must be equipped with a wall mount and properly secured. Housings mounted to ceiling must be equipped with a ceiling mount that is specifically manufactured for ceiling mount applications. Mounting wall mount housings upside down in a ceiling application will not be accepted. Housing shall be provided with "Feed Through" mounting hardware for protection of signal and low-voltage power cable. Housings without heater and blower will be accepted in the covered areas of the between wings. Liquid-tight fittings and conduit shall be used for routing of any cable that is not fed through the camera mount. All exterior housings shall be provided with tamper resistant kit, and mounting hardware. Reference manufacturer guidelines for mounting requirements.
- C. Reference CCTV details and CCTV schedule for housing types required.
- D. Acceptable manufacturers shall include BOSCH or approved equal.

## 2.07 VIDEO MANAGEMENT SOFTWARE

- A. The Security Contractor shall be required to coordinate and include all associated costs for all required customized programming for the VMS per the requirements of the owner. Contractor shall provide, install and configure all software / hardware upgrades required for adding all cameras in project to existing system. Contractor also to provide all required programming and linking for complete integration with access control system.

## 2.08 COPPER WIRING REQUIREMENTS

- A. Video & Data cables shall be 100 Ohm, 0.5mm, un-shielded twisted pair (UTP), 23 AWG, with solid copper conductors. Cables shall exceed ANSI/TIA/EIA-568-B.2 Category 6 requirements and the spool shall be labeled as such. Cables shall be tested to 350 MHz Cables shall be UL or ETL verified to exceed Category 6 requirements and cable jacket shall be labeled to indicate verification.
- B. Contractor to provide outside-plant (OSP) rated cabling where cabling is installed outdoors, underground, or in slab on-grade.

- C. Contractor to provide plenum rated cable when cables are installed in above ceiling plenum spaces.
- D. Acceptable manufacturers shall include:
  - 1. See Telecom Infrastructure Specifications

#### 2.09 UNINTERRUPTIBLE POWER SUPPLY (UPS)

- A. Furnish and install uninterruptible power supply (UPS) at the location of the video surveillance equipment in the Telecom Room. UPS system to provide battery backup for a minimum of 30 minutes and be rack mounted in low voltage equipment rack.
- B. The UPS shall be an on-line double conversion UPS which shall have the following minimum features:
  - 1. Audible Alarms
  - 2. Automatic Self-Test
  - 3. Automatic Voltage Regulation (AVR)
  - 4. Building wiring fault indicator
  - 5. Lightning and Surge Protection
  - 6. Network-grade line conditioning
  - 7. Overload Indicator
  - 8. Rack Mount
  - 9. Replace Battery Indicator
  - 10. Status Indicator LED's
  - 11. UPS shall have the ability to handle crest factor ratios of 2.5 or above.
  - 12. UPS shall provide continuous (no-break power) during momentary or complete blackouts.
  - 13. UPS shall have the ability to recharge the battery to 90 percent capacity within a reasonable period of time (5 to 10 times the discharge time).
  - 14. The UPS output shall be regulated with maximum deviations from nominal of +6 percent to -13 percent over the full input range, both AC and DC.
  - 15. UPS shall meet ANSI C84.1 requirements.
- C. Provide load calculations used for sizing UPS.
- D. The approved manufactures shall be APC, Tripp Lite, Falcon or approved equal.

#### 2.10 TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS)

- A. Protect all equipment against surges induced on all control, video, and power cables. All copper cables and conductors which serve as 120V power, control, or

video conductors shall have surge protection circuits installed at each end and locations where conductors enter or exit a building. Fuses shall not be used for surge protection. On board surge suppression will not be acceptable. External surge suppression, as described in this section, is required.

- B. Protect all devices mounted on the exterior of the building with surge suppression devices mounted at the device and grounded per manufacturer's recommendations.
- C. Surge suppression devices shall meet the following standards/publications:
  - 1. UL 497B
  - 2. UL 1449 (must meet 330 Volt suppression rating)
  - 3. IEEE Category B impulse and ring wave tests
- D. Acceptable Manufacturers: Ditek. Product shall be warranted against defect for a period of not less than five (5) years.
- E. All power connections, including 24 VDC and 24 VAC power supplies and direct wired or plug-in 120 VAC power connections, for all systems and components specified herein, shall be equipped with surge suppression devices. Devices shall be bonded to building grounding system in accordance with Article 250 of the National Electric Code.
- F. Grounding: Provide a dedicated, separate No. 6 AWG copper conductor from building grounding system to the video equipment room, video equipment cabinets, and central control room. Connect all lightning protection devices and video equipment non-current carrying metal parts to grounding conductor in accordance with Article 250 of the National Electric Code. Provide ground bus bar in equipment room and control room with dedicated ground conductor to each cabinet, enclosure, pull/junction box and all equipment.
- G. Ground Resistance Measurement: Each signal ground system D.C. resistance shall be measured between any point on the signal ground bus and the earth ground. An instrument designed specifically to measure the resistance of a point to each earth ground shall be used. The systems subcontractor shall measure ground resistance in accordance with the procedure as outlined by the test equipment manufacturer.

## 2.11 PARKING DECK HARDENED GIGABIT POE+ NETWORK SWITCH

- A. The fiber optic hardened Gigabit POE+ Ethernet transceivers shall transmit/receive IP signals over standard multi-mode or single mode fiber optic cable. Coordinate with floor plans and one-line diagrams.

- B. Industrial Switches shall provide continuous uptime, manageability and operational efficiency, with full PoE+ power per PoE port.
- C. System features include:
  - 1. Full Wire Speed Layer 2 Switching
  - 2. All PoE ports IEEE 802.3af and 802.3at compliant and support up to 30W concurrently
  - 3. Dual DC power input and reverse power protection
  - 4. -40°C to +75°C operating temperature
  - 5. Form Factor: DIN Rail or Wall Mountable plus Rugged IP30 Enclosure
  - 6. Highly Resilient LACP, Spanning tree STP, RSTP & MSTP, fast Ring fail-over and G.8032 ERPS protection options
  - 7. Port-based /tag-based VLAN, IEEE 802.1ad/QinQ VLAN
  - 8. IGMP v1/v2/v3, multicast proxy and snooping
  - 9. Multicast/Broadcast/Flooding Storm Control
  - 10. PoE PSE power management and PD power consumption
- D. Basis of design is the Extreme Networks Extreme Switching Industrial Ethernet Switches model #10/100/1000 POE+ models or approved equals.

## 2.12 ETHERNET MEDIA CONVERTER FOR ELEVATOR CAMERAS

- A. Minimum configuration shall be:
  - 1. 56VDC distributed over 2-wire cable to all connected IP devices Powers PoE entry stations (or other PoE or PoE+ devices), up to 50 watts\*
  - 2. Each device / port shall meet EEPoE standards
  - 3. Built-in transient protection; Industrial temperature range
  - 4. Transmit 10/100 BaseT Ethernet up to 1,000ft (305m) \* over 4-pair cat5; 750ft (228m) over 18/2 (or similar 2-wire cable); 500ft (150m) over Shielded Twisted-Pair
- B. Basis-of-Design is NVT PHYBRIDGE model #NV-EC1701U – Ethernet over 2 wire transceiver with PoE power

## PART 3 – EXECUTION

### 3.01 INSTALLATION

- A. System components and appurtenances shall be installed in accordance with NFPA 70, manufacturer's instructions, and as shown. Necessary interconnections, services, and adjustments required for a complete and

operable signal distribution system shall be provided. Penetrations in fire-rated construction shall be fire-stopped in accordance with contract documents. Conduits and raceways shall be installed in accordance with the National Electric Code (NEC). Cables shall not be installed in the same cable tray, utility pole compartment, or floor trench compartment with AC power cables. Contractor to provide ground isolation between buildings by breaking continuous copper cabling and metal conduit runs.

- B. Equipment: All monitor support brackets shall be securely attached to mounting surfaces. Use lead shields on solid masonry, wood screws on wood, and machine bolts on structural steel. All anchoring devices shall be rated to support not less than five times the total equipment weight.
- C. Surge Protection:
  - 1. All copper cables and conductors which serve as control, power, or data conductors shall have surge protection devices installed at each end that complies with electrical and security specifications.
  - 2. Protect all video and data equipment from surges induced on all control, power and data cables. All copper cables and conductors which serve as control, power, or data conductors shall have surge protection circuits installed at each end that meet the IEEE 472 surge withstand capability test. Fuses shall not be used for surge protection.
- D. Power: All interior and exterior cameras shall be powered from central power supplies in the security equipment rooms.

### 3.02 SYSTEM INTEGRATION & CUSTOMIZATION

- A. The contractor shall be required to meet with the owner representative for the purpose of completely customizing the system. The contractor shall include all associated costs for all programming. Programming shall consist of setting individual camera record rates, configuring video motion detection zones and programming alarm inputs, etc.

### 3.03 TESTING

- A. Materials and documentation to be furnished under this specification are subject to inspections and tests. All components shall be terminated prior to testing. Equipment and systems will not be accepted until the required inspections and tests have been made, demonstrating that the video distribution system conforms to the specified requirements, and that the required equipment, systems, and documentation have been provided.

### 3.04 TRAINING

- A. The Contractor shall include in the base Contract all costs required to train the operating and maintenance personnel in the use and maintenance of systems provided under this section of the Specifications. Training sessions shall be conducted by instructors certified in writing by the manufacturer of the specific system.
- B. Training session requirements shall include two (2) – two-hour sessions. Up to two (2) sessions may be held on the same day. Training session schedules shall conform to the requirements of the owner; therefore, such schedules shall be submitted to the owner for approval not less than two weeks prior to the training session. All training sessions shall be video-taped for future use. Training sessions shall include instruction on changing camera text identifiers.
- C. Time to be included in base Contracts for specific systems shall be as follows:
  - 1. Video Surveillance System - 4 hours

### END OF SECTION

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**SECTION 311000 - SITE CLEARING****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

**1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Protecting existing trees, shrubs, groundcovers, plants, and grass, to remain.
  - 2. Removing existing trees, shrubs, groundcovers, plants, and grass as indicated on drawings.
  - 3. Clearing and grubbing.
  - 4. Removing above- and below-grade site improvements.
  - 5. Disconnecting, capping or sealing, and removing site utilities.
  - 6. Temporary erosion and sedimentation control measures.
- B. Related Sections include the following:
  - 1. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.

**1.3 DEFINITIONS**

- A. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

**1.4 QUALITY ASSURANCE**

- A. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."

**1.5 PROJECT CONDITIONS**

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
  - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
  - 2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
- B. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

- C. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.
- D. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.

## **PART 2 - PRODUCTS**

### **2.1 SOIL MATERIALS**

- A. Satisfactory Soil Materials: Requirements for satisfactory soil materials are specified in Division 31 Section "Earth Moving."
  - 1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available on-site.

## **PART 3 - EXECUTION**

### **3.1 PREPARATION**

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Locate and clearly flag trees and vegetation to remain or to be relocated.
- C. Protect existing site improvements to remain from damage during construction.
  - 1. Restore damaged improvements to their original condition, as acceptable to Owner.

### **3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL**

- A. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to requirements of authorities having jurisdiction and in accordance with sediment and erosion control Drawings.
- B. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.
- C. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

### **3.3 TREE PROTECTION**

- A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.
  - 1. Do not store construction materials, debris, or excavated material within fenced area.
  - 2. Do not permit vehicles, equipment, or foot traffic within fenced area.

3. Maintain fenced area free of weeds and trash.

B. Do not excavate within tree protection zones, unless otherwise indicated.

C. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.

### 3.4 UTILITIES

A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.

1. Arrange with utility companies to shut off indicated utilities.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Construction Manager not less than two days in advance of proposed utility interruptions.

2. Do not proceed with utility interruptions without Construction Manager's written permission.

C. Excavate for and remove underground utilities indicated to be removed.

### 3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.

2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.

3. Grind stumps and remove roots, obstructions, and debris extending to a depth of 18 inches below exposed subgrade.

4. Use only hand methods for grubbing within tree protection zone.

5. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

### 3.6 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.7 DISPOSAL

- A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

**END OF SECTION 311000**

**SECTION 312000 - EARTH MOVING****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

**1.2 SUMMARY**

- A. This Section includes the following:
  - 1. Preparing subgrades for slabs-on-grade, walks, pavements, lawns and grasses, and exterior plants.
  - 2. Excavating and backfilling for buildings and structures.
  - 3. Drainage course for slabs-on-grade.
  - 4. Subbase course for concrete walks and pavements.
- B. Related Sections include the following:
  - 1. Division 31 Section "Site Clearing" for temporary erosion and sedimentation control measures, site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
  - 2. Division 32 Section "Turf and Grasses" for finish grading, including preparing and placing topsoil and planting soil for lawns.
  - 3. Division 32 Section "Plants" for planting bed establishment and tree and shrub pit excavation and planting.

**1.3 DEFINITIONS**

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
  - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
  - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Course placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Course placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Drainage Course: Course supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
- G. Fill: Soil materials used to raise existing grades.

- H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- I. Subbase Course: Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- J. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.
- K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

#### 1.4 SUBMITTALS

- A. Product Data: For the following:
  - 1. Geotextile.
  - 2. Controlled low-strength material, including design mixture.

#### 1.5 QUALITY ASSURANCE

- A. Codes and Standards: Perform earthwork complying with requirements of authorities having jurisdiction.
- B. Geotechnical Testing Agency Qualifications: Owner will employ and pay a qualified, independent geotechnical testing laboratory to perform soil testing and inspection services during earthwork operations. Contractor shall be responsible for scheduling and coordination of these services.
- C. Preexcavation Conference: Before commencing earthwork, meet with representatives of governing authorities, Owner, Architect, Structural Engineer, consultants, Geotechnical Testing Agency and other concerned entities. Review earthwork procedures and responsibilities including testing and inspection procedures and requirements. Notify participants at least three working days prior to convening conference. Record discussions and agreements and furnish a copy to each attendee.

#### 1.6 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Construction Manager and then only after arranging to provide temporary utility services according to requirements indicated.
  - 1. Notify Construction Manager not less than two days in advance of proposed utility interruptions.
  - 2. Do not proceed with utility interruptions without Construction Manager's written permission.
  - 3. Contact utility-locator service for area where Project is located before excavating.
- B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

## **PART 2 - PRODUCTS**

### **2.1 SOIL MATERIALS**

- A. General: Provide off-site borrow soil materials when sufficient satisfactory soil materials are not available from on-site excavations.
- B. Satisfactory Soils: On site soils satisfactory to testing agency, containing less than 25% pulverized shale fragments, free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, organics, vegetation, and other deleterious matter.
- C. Unsatisfactory Soils: Silt, highly organic soils, wood, roots, trash, debris, and other soils and materials not acceptable to the testing agency.
  - 1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
- D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.
- F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.
- H. Drainage Course: Narrowly graded mixture of washed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.
- I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and 0 to 5 percent passing a No. 4 sieve.
- J. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand.
- K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

### **2.2 GEOTEXTILES**

- A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; as noted on drawings.

- B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; as noted on the drawings.

### **PART 3 - EXECUTION**

#### **3.1 PREPARATION**

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- B. Protect and maintain erosion and sedimentation controls during earthwork operations.
- C. Provide protective insulating materials to protect subgrades and foundation soils against freezing temperatures or frost.

#### **3.2 DEWATERING**

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
  - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated utility trenches as temporary drainage ditches.
  - 2. Install a dewatering system to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.

#### **3.3 EXPLOSIVES**

- A. Explosives: Do not use explosives.

#### **3.4 EXCAVATION FOR STRUCTURES**

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
  - 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

#### **3.5 EXCAVATION FOR WALKS AND PAVEMENTS**

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

### 3.6 EXCAVATION FOR UTILITY TRENCHES

- A. For sanitary sewer, storm sewer, and water lines, please see the corresponding spec sections. For other site utilities follow below.
- B. Excavate trenches to indicated gradients, lines, depths, and elevations.
  - 1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
- C. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit, unless otherwise indicated.
  - 1. Clearance: 12 inches each side of pipe or conduit.
- D. Trench Bottoms: Excavate trenches 4 inches deeper than bottom of pipe elevation to allow for bedding course. Hand excavate for bell of pipe.
  - 1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

### 3.7 SUBGRADE INSPECTION

- A. Notify testing agency when excavations have reached required subgrade.
- B. If testing agency determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
- D. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Construction Manager, without additional compensation.

### 3.8 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill may be used when approved by Geotechnical Engineer.
  - 1. Fill unauthorized excavations under other construction or utility pipe as directed by Construction Manager.

### 3.9 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
  - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

### 3.10 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
  - 1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
  - 2. Surveying locations of underground utilities for Record Documents.
  - 3. Testing and inspecting underground utilities.
  - 4. Removing concrete formwork.
  - 5. Removing trash and debris.
  - 6. Removing temporary shoring and bracing, and sheeting.
  - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.

### 3.11 UTILITY TRENCH BACKFILL

- A. For sanitary sewer, storm sewer, and water lines, please see the corresponding spec sections. For other site utility backfill, follow below.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.
- C. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- D. Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings.
- E. Provide 4-inch- thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase.
- F. Place and compact initial backfill material, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the utility pipe or conduit in non-paved areas.
  - 1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
- G. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches over the utility pipe or conduit in paved areas.
- H. Backfill voids with satisfactory soil while installing and removing shoring and bracing.
- I. Place and compact final backfill of satisfactory soil to final subgrade elevation in non-paved areas.
- J. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation in paved areas.

### 3.12 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers to required elevations in accordance with sections 3.13 and 3.14 and as follows:
  - 1. Under grass and planted areas, use satisfactory soil material or engineered fill.
  - 2. Under walks and pavements, use satisfactory soil material (excluding topsoil) or engineered fill.
  - 3. Under steps and ramps, use satisfactory soil material (excluding topsoil) or engineered fill.
  - 4. Under building slabs, use satisfactory soil material (excluding topsoil) or engineered fill.
  - 5. Under footings and foundations, use satisfactory (excluding topsoil) soil material or engineered fill.
- C. Place soil fill on subgrades free of mud, frost, snow, or ice.

### 3.13 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
  - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
  - 2. Remove and replace, or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

### 3.14 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698:
  - 1. Under structures, building slabs, steps, and pavements, including 10 feet beyond all such areas, compact each layer of backfill or fill soil material at 100 percent maximum dry density.
  - 2. Under walkways, compact each layer of backfill or fill soil material at 100 percent maximum dry density.
  - 3. Under lawn or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 95 percent maximum dry density.
  - 4. For utility trenches, compact each layer of initial and final backfill soil material at 100 percent maximum dry density.

**3.15 GRADING**

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
  - 1. Provide a smooth transition between adjacent existing grades and new grades.
  - 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
  - 1. Lawn or Unpaved Areas: Plus or minus 1 inch.
  - 2. Walks: Plus or minus 1 inch.
  - 3. Pavements: Plus or minus 1/2 inch.
- C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

**3.16 SUBSURFACE DRAINAGE**

- A. Subdrainage Pipe: Specified in Division 33 Section "Subdrainage."
- B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
  - 1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.
- C. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with 1 layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
  - 1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.

**3.17 SUBBASE AND BASE COURSES**

- A. Place subbase and base course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase and base course under pavements and walks as follows:
  - 1. Where specified install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
  - 2. Shape subbase and base course to required crown elevations and cross-slope grades.
  - 3. Place subbase and base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
  - 4. Compact subbase and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 98 percent of maximum dry density.

- C. Pavement Shoulders: Place shoulders along edges of subbase and base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each subbase and base layer to not less than 100 percent of maximum dry density.

### 3.18 DRAINAGE COURSE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
  - 1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
  - 2. Place drainage course 6 inches or less in compacted thickness in a single layer.
  - 3. Place drainage course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
  - 4. Compact each layer of drainage course to required cross sections and thicknesses to not less than 98 percent of maximum dry unit weight according to ASTM D 698.

### 3.19 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.
- B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.
- C. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.

### 3.20 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
  - 1. Scarify or remove and replace soil material to depth as directed by Construction Manager; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
  - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Transport surplus soil material offsite to a legal disposal site off Owner's property.
  - 1. Remove waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.
- B. Excavated pavements shall be considered waste material and shall not be incorporated into fills.

**END OF SECTION 312000**

## **SECTION 31 63 20**

### **DRILLED PIERS**

#### **PART 1 GENERAL**

##### **1.1 RELATED DOCUMENTS**

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

##### **1.2 SUMMARY**

- A. Section includes all labor, material, equipment, special tools and services required to complete all drilled pier work, as herein specified, and as indicated on the Drawings, including but not limited to:
  - 1. Drilling and excavation of pier shafts.
  - 2. Metal casings or shells.
  - 3. Protection of shaft openings.
  - 4. Removal of steel casings or shells.
  - 5. Removal of excavated materials.
  - 6. Concrete and reinforcement for drilled piers.
- B. Related Sections:
  - 1. Section 03 30 00 - Cast-in-Place Concrete.
  - 2. Section 31 20 00 - Earthwork.
- C. Unit prices:
  - 1. Drilled Pier Work shall be on a lump sum basis, based on the sizes and total lengths of drilled piers shown on the Drawings.
  - 2. Unit prices per linear foot for each shaft diameter shall be provided as set forth in the Bid Form for adjustment of Contract Sum by Change Order to reflect net difference between total of design lengths and actual length of piers installed.
  - 3. These unit prices shall apply to both net overages and underages and shall include the costs of drilling, casing, cleaning, concreting, reinforcing, and all other costs associated with the change in footage.
  - 4. Provide separate unit costs for the length of drilled piers installed in rock and the length of drilled piers installed above the rock sockets specified herein and indicated on the Drawings.
  - 5. No payment will be made for increases in concrete volume due to causes other than length change.
  - 6. No payment will be made for over-drilling not directed by the Geotechnical Engineer. Fill the extra depth with concrete if all other conditions are satisfactory.

### 1.3 REFERENCES

- A. Comply with the provisions of the latest edition of the following codes, specifications and standards unless a date is indicated. Modifications in this specification, when in conflict with the referenced codes, specifications and standards, shall take precedence.
  - 1. Kentucky Building Code (KBC).
  - 2. ACI (American Concrete Institute) 336.1-01: Specification for the Construction of Drilled Piers Structures is hereby incorporated as part of this Section. Supplemental requirements and modifications listed herein take precedence over the requirements of ACI 336.1. All ACI 336.1 items unless modified by the Contract Documents are incorporated as written. When any part of any item is modified or voided, the unaltered provisions of the part shall apply as written.
  - 3. ACI 301-16: Specifications for Structural Concrete.
  - 4. CRSI (Concrete Reinforcing Steel Institute) Manual of Standard Practice, 28<sup>th</sup> Edition.
- B. A copy of each reference shall be kept in the project's field office at all times. They shall govern the work except as herein modified.

### 1.4 SUBMITTALS

- A. Submit documentation to demonstrate compliance with the Contractor qualifications noted below. Include experience record of supervisory personnel and drillers.
- B. Submit written description of equipment and techniques proposed for use, and names of three similar projects completed by installer in last three years.
- C. Submit plan layout of drilled piers along with reinforcing steel shop drawings.
- D. Submit proposed concrete mix design per Section 03 30 00 – Cast-in-Place Concrete.
- E. Submit a quality control program per ACI 336.1.
- F. At regular intervals, the Geotechnical Engineer's Representative will submit drilling logs to the Owner, Architect/Engineer, Contractor, and Construction Manager with the following information:
  - 1. Identification mark.
  - 2. Shaft diameter.
  - 3. Bottom elevation.
  - 4. Top elevation.
  - 5. Bearing strata description.
  - 6. Depth of penetration in bearing strata.
  - 7. Length and location of any permanent casing.
  - 8. Nature and location of obstructions, including durations.
  - 9. Water conditions during drilling and concrete placement.
  - 10. Deviation from design centerline location and deviation from plumb.

## 1.5 QUALITY ASSURANCE

### A. Qualifications:

1. Drilled piers shall be installed by a specialty Contractor with a minimum of ten years of experience in drilled pier construction.
2. Personnel performing the work shall have experience with similar subsurface materials, water conditions, pier sizes, and special techniques required.
3. Contractor shall have successfully completed at least five contracts with similar type soils, bearing stratum, pier diameters and project size.

### B. Contractor shall engage a Kentucky-registered surveyor to perform surveys, layouts, and measurements for drilled pier work. Coordinate with services of Geotechnical Engineer's Representative.

### C. Comply with ACI 336.1.

### D. Comply with applicable laws, ordinances, and the Kentucky Building Code.

### E. A Representative of the Owner's Geotechnical Engineer will conduct construction review services to monitor all drilled pier work, examine prepared bearing surfaces, and establish the final installation elevation to which pier bottoms are to be drilled.

### F. Testing of concrete in the field will be performed by the Geotechnical Engineer's Representative or a separate independent Testing Agency retained by the Owner.

### G. The Contractor shall select and employ an independent testing agency, subject to the Architect/Engineer's approval, to perform all testing required by the Contractor for qualification of proposed materials, establishment of mix designs, and for all other testing services needed or required by the Contractor.

## 1.6 DELIVERY, STORAGE, AND HANDLING

### A. Store pier casings and reinforcing steel above ground on platforms.

### B. Protect materials from damage, exposure and corrosion.

### C. Drilled pier casings or shells ordered and delivered to the site prior to verification of the assumed working capacities and establishment of criteria for excavating piers shall be at the risk of the Contractor.

## 1.7 PROJECT CONDITIONS

### A. Geotechnical information:

1. Subsurface Information: A report of the subsurface investigation for the project, prepared by the Owner's Geotechnical Engineer, is available to bidders for review.
2. Data on indicated subsurface conditions are not intended as representatives or warranties of continuity of such conditions. It is expressly understood that Owner and Architect/Engineer will not be responsible for interpretations or conclusions made by the Contractor.
3. Data is made available for the convenience of the Contractor and is not guaranteed to represent conditions that may be encountered.

4. It is required that all Contractors or Subcontractors submitting bids for this part of the Work visit the site and make whatever additional investigations, including drilled test holes, they deem necessary to prepare their bids. All test holes shall be filled immediately after investigation is completed to the satisfaction of the Owner.
  5. No claim for additional compensation or extension of Contract time will be allowed on account of subsurface conditions inconsistent with the data available except as provided elsewhere herein.
- B. Drilled piers will penetrate natural soils, rock and fill. Areas of old pavement, limestone floaters, debris, other obstructions, and water may be encountered. Contractor shall, within the Base Bid, be responsible for penetrating all obstructions, preventing all caving of soils surrounding holes, and providing all water protection and dewatering.
  - C. Drilled piers may be installed in close proximity to existing spread footings which are presumed to bear at shallow depths. Contractor shall advance casings as the holes are drilled and take other precautions as necessary to protect existing foundations located at high bearing elevations.
  - D. Existing Utilities: Locate existing underground utilities in areas of drilled pier installation. If utilities are to remain in service provide adequate support and protection. Refer to Drawings for additional utilities information.
  - E. Protection: Protect structures and other construction from damage caused by drilled pier operations.

#### 1.8 SUPPLEMENTAL REQUIREMENTS AND MODIFICATIONS TO ACI 336.1

- A. The following statements modify and supplement ACI 336.1. All unaltered parts of ACI 336.1 shall apply as written. The Section and paragraph numbers correspond to those in ACI 336.1.

#### SECTION 1 (ACI 336.1) – GENERAL REQUIREMENTS

- 1.6.1.1 Examine areas and conditions under which drilled pier work is to be performed. Notify Construction Manager of conditions detrimental to proper and timely completion of the Work. Starting of work constitutes acceptance of existing conditions.
- 1.6.1.2 Do not install drilled piers until required earthwork in the area in which the drilled piers are to be installed has been completed.
- 1.6.3.1 Before drilling, verify locations of underground utilities with the utility companies and/or Owner. Excavate or survey to establish exact utility locations.
- 1.6.3.1 Active utilities shown on the Drawings shall be adequately protected from damage. Where active utilities are encountered but not shown on the Drawings, the Construction Manager, Architect/Engineer and utility owner shall be advised; the work shall be protected, supported, or relocated as directed; and the Contract Sum adjusted.

- 1.6.3.2 Inactive and abandoned utilities encountered shall be reported to the Construction Manager and Architect/Engineer. Utilities shall be removed, plugged or capped as directed by the Architect/Engineer or utility owner. In absence of specific requirements, plug or cap such utility lines as required by the local regulations.
- 1.6.4.1 The Construction Manager shall arrange a pre-construction meeting to be held a minimum of one week before the scheduled start of drilled pier operations. The meeting shall be attended by the Drilled Pier Contractor, Construction Manager, Structural Engineer, Geotechnical Engineer, Testing Agency, and Drilled Pier Contractor's Surveyor. The purpose of the meeting is to review:
  - a. Drilled pier installation procedures.
  - b. Drilled pier inspection and material testing procedures.
  - c. Contractor's procedures for surveying and documenting locations of existing utilities adjacent to drilled piers.
  - d. Disposal of drilled pier spoils.

## SECTION 2 (ACI 336.1) – PRODUCTS

- 2.2.3.1 Casings shall be a constant circular section with a minimum nominal inside diameter of shaft sizes called for on the Drawings.
- 2.3.1 Reinforcing steel shall comply with Section 03 30 00 – Cast-in-Place Concrete and have a minimum yield strength of 60 ksi.
- 2.4.1.1 Concrete strength and mix design shall comply with Section 03 30 00 – Cast-in-Place Concrete.
- 2.4.3.1 Slump of concrete placed in dry holes that are uncased or which have permanent casing shall be 5 in. plus or minus 1 in. Slump of concrete placed in holes with temporary casing shall be 7 in. plus or minus 1 in. If required, use high-range water-reducer in concrete to provide required slump without exceeding maximum allowable water-cementitious materials ratio specified in Section 03 30 00 – Cast-in-Place Concrete.
- 2.7 Drilling equipment
  - 2.7.1 Drilled piers shall be installed with portable drilling rigs equipped with two-way leveling and two-way horizontal positioning. Rigs shall have adequate power, weight and shaft length to meet Project requirements.

## SECTION 3 (ACI 336.1) – EXECUTION

- 3.1.1.1 If specified tolerances for plan location or plumbness are exceeded, provide at no additional cost to Owner corrective measures to compensate for the excess eccentricity. Do not proceed until proposed corrective construction methods have been submitted to and accepted by Architect/Engineer.
- 3.1.2 Location tolerance at cut-off shall be no greater than 1/24 of the specified shaft diameter or 3 in., whichever is less.

- 3.1.3 Out-of-plumbness of piers shall not exceed 1.5% of length, nor 12.5% of shaft diameter, nor 15 in., whichever is less.
- 3.1.5 Maximum slope of bottom of drilled pier shall be 1/4 in. per foot.
- 3.1.7.1 Tolerances for placing anchor bolts and other embedded items for structural steel work (Section 05 12 00) shall be in accordance with the AISC Code of Standard Practice for Steel Buildings and Bridges.
- 3.1.7.2 Tolerance on horizontal location of dowels placed in tops of drilled piers shall be plus or minus 1/4 in., based on Contract Document location.
- 3.1.8 Tolerance on vertical deviation of top surface of drilled piers shall be plus 1 in. to minus 3 in.
- 3.1.9 Tolerance on drilled pier reinforcement shall be plus or minus 1/2 in., horizontal and vertical, based on actual pier location.
- 3.2.1.1 Drilled piers shall extend minimum 0'- 6" into unweathered shale bedrock for 30 ksf bearing, unless noted otherwise on the Drawings.
- 3.2.1.2 Bottom elevations and bearing capacities and lengths of drilled piers as shown on Drawings and specified herein are estimated from available subsurface data. Actual elevations, drilled pier lengths, and bearing capacities will be determined by Geotechnical Engineer from conditions found in excavations. Final evaluations and acceptance of data will be by Architect/Engineer.
- 3.2.2.1 Exercise care during drilling operations, so that soil will not slough or cave-in due to drilling. Distribute equipment loads to prevent cave-ins.
- 3.2.2.2 Protect drilled shaft openings from earth falling in due to drilling of adjacent shafts.
- 3.2.3 Each drilled pier shaft shall be inspected by Geotechnical Engineer's Representative to insure that the drilled pier bears on suitable material and that the shaft is free of debris and water. Do not begin concrete work until shaft is inspected and approved.
- 3.2.3.2.1 Case and provide proper safety equipment for any shaft into which workmen or an inspector will enter.
- 3.2.5.1 Remove material likely to scale off walls of drilled piers and thoroughly clean bottom, removing all loose material.
- 3.2.5.2 Pump and remove all water encountered in the drilled pier shafts. Do not allow water to sit on bearing surfaces of pier. Remove any deteriorated bearing material before concreting.
- 3.2.7.1 Dispose of all cuttings from the drilling operation off the Project site, unless otherwise directed by the Construction Manager.

- 3.2.8 Alternate drilling and concreting closely spaced piers. Do not drill a pier closer than 10 feet to an existing pier less than three days old.
- 3.2.9 All drilled shaft openings not immediately filled with concrete shall be temporarily protected with a metal lid, spot welded in place.
- 3.2.10 Record and maintain information pertinent to each drilled pier, including actual measurements of each drilled pier's horizontal axial location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other data as required. Make this information available to the Geotechnical Engineer's Representative for inclusion in the drilling log submittals.
- 3.4.7.1 Splicing of vertical reinforcing bars for the pier shafts, other than as approved by the Architect/Engineer, shall not be permitted.
- 3.4.10.1 Insert steel reinforcing cage and wedge in place immediately after drilling and inspection. Reinforcing cages shall be rigidly tied, accurately located in shaft and adequately blocked to maintain the location and clearance shown on the Drawings.
- 3.4.12 Protect exposed portions of dowels and anchor bolts from mechanical damage and exposure to weather. Band tops of dowel cages with 2 in. wide bright orange ribbons.
- 3.5.4.1 Place concrete immediately after approval by Geotechnical Engineer's Representative and installation of reinforcing. Concrete to be placed the same day the shaft excavation is completed.
- 3.5.6.1 Place concrete to avoid segregation. In dry holes (defined as 1/4 in. or less rise per minute in groundwater at bottom of hole with total depth no greater than 2 in.) concrete may be placed by unobstructed free fall down the center of the shaft. In wet holes concrete shall be placed by tremie methods or by pumping in a manner acceptable to the Geotechnical Engineer's Representative.
- 3.5.6.2 Vibrate upper 20 feet of each drilled pier.
- 3.5.7.1 Place concrete in each drilled pier continuously without interruption.
- 3.5.7.2 Protect top of drilled pier from entry of soil or foreign matter during concrete placement and until concrete has set.
- 3.5.10.1 Cure top and all formed concrete surfaces per Section 03 30 00 - Cast-in-Place Concrete.
- 3.5.11 Form the top of drilled piers as necessary wherever grade is below scheduled top of drilled pier at time of concrete placement.
- 3.9 Field Quality Control and Assurance

- 3.9.1 Drilled piers shall be installed under the full-time monitoring of the Geotechnical Engineer's Representative. Provide facilities required to assist in the inspection and testing of excavations, and cooperate with inspecting and testing personnel to expedite the work.
- 3.9.2 Owner will select and pay an independent Testing Laboratory to secure and test cylinders, perform slump tests, and ensure compliance with Specifications. Contractor is required to arrange for all testing. Also refer to Section 03 30 00 - Cast-in-Place Concrete.
- 3.9.3 Owner's Testing Agency will take one set of four 6 by 12 in. cylinders or one set of five 4 by 8 in. cylinders for each 150 cubic yards of concrete, or fraction thereof, placed in any one day. One cylinder will be tested in compression at 7 days and two 6 by 12 in. cylinders or three 4 by 8 in. cylinders will be tested at 28 days in accordance with ASTM C 39. One cylinder will be kept in reserve for additional testing if required.
- 3.9.4 Owner's Testing Agency may take core samples of in-place concrete when inspections or test results are such that there is reasonable doubt about the quality of concrete, or specified concrete strengths have not been attained.
  - 1. Complete continuous coring of drilled piers may be required, at Drilled Pier Contractor's expense, where time of removal of temporary casings exceeds specified limits, or where observations of placement operations indicates cause for suspicion of quality of concrete, presence of voids, segregation or other possible defects.
  - 2. Defective piers shall be corrected by the addition of piers and/or cap beams by the Contractor at no additional cost to the Owner

## **PART 2 PRODUCTS**

- 2.1 PRODUCT REQUIREMENTS ARE INCLUDED IN ARTICLE 1.8 ABOVE.

## **PART 3 EXECUTION**

- 3.1 EXECUTION REQUIREMENTS ARE INCLUDED IN ARTICLE 1.8 ABOVE.

## **END OF SECTION**

**SECTION 321216 - ASPHALT PAVING****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

**1.2 SUMMARY**

- A. Section Includes:
  - 1. Hot-mix asphalt patching.
  - 2. Hot-mix asphalt paving.
  - 3. Hot-mix asphalt paving overlay.
  - 4. Asphalt surface treatments.
  - 5. Pavement-marking paint.
  - 6. Wheel Stops.
- B. Related Sections:
  - 1. Division 02 Section "Structure Demolition" for demolition, removal, and recycling of existing asphalt pavements, and for geotextiles that are not embedded within courses of asphalt paving.
  - 2. Division 31 Section "Earth Moving" for aggregate subbase and base courses and for aggregate pavement shoulders.
  - 3. Division 32 Sections for other paving installed as part of crosswalks in asphalt pavement areas.
  - 4. Division 32 Section "Concrete Paving Joint Sealants" for joint sealants and fillers at paving terminations.

**1.3 DEFINITION**

- A. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.
- B. KYTC: Kentucky Transportation Cabinet

**1.4 SUBMITTALS**

- A. Material Certificates: For each paving material, from manufacturer.

**1.5 QUALITY ASSURANCE**

- A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located.
- B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

- C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the Kentucky Transportation Cabinet for asphalt paving work.
  - 1. Measurement and payment provisions and safety program submittals included in standard KYTC specifications do not apply to this section.
- D. Preinstallation Conference: Conduct conference at Project site.
  - 1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
    - a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
    - b. Review condition of subgrade and preparatory work.
    - c. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
    - d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.

## 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.
- B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

## 1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
  - 1. Prime Coat: Comply with weather limitations as per KYTC Standard Specifications.
  - 2. Tack Coat: Comply with weather limitations as per KYTC Standard Specifications.
  - 3. Asphalt Base Course: Comply with weather limitations as per KYTC Standard Specifications.
  - 4. Asphalt Surface Course: Comply with weather limitations as per KYTC Standard Specifications.
- B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil-based materials, and 55 deg F for water-based materials, and not exceeding 95 deg F.

## PART 2 - PRODUCTS

### 2.1 AGGREGATES

- A. General: Use materials complying with the KYTC Standard Specifications as indicated on the plans.

## 2.2 ASPHALT MATERIALS

- A. Asphalt Binder: Use materials complying with KYTC Standard Specifications as indicated on the plans.
- B. Asphalt Cement: Use materials complying with KYTC Standard Specifications as indicated on the plans.
- C. Prime Coat: Use materials complying with KYTC Standard Specifications.
- D. Tack Coat: Use materials complying with KYTC Standard Specifications as indicated on the plans.
- E. Water: Potable.

## 2.3 AUXILIARY MATERIALS

- A. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.
- B. Paving Geotextile: As specified on plans.
- C. Joint Sealant: ASTM D 6690 or AASHTO M 324, Type II or III, hot-applied, single-component, polymer-modified bituminous sealant.
- D. Pavement-Marking Paint: KYTC Item 713.
  - 1. Color: White, Yellow, & Blue.
- E. Wheel Stops: Precast, air-entrained concrete, 3500-psi minimum compressive strength, see drawings for dimensions. Provide chamfered corners, drainage slots on underside, and holes for anchoring to substrate.
  - 1. Dowels: 2 - Galvanized steel, minimum 1/2-inch diameter.

## 2.4 MIXES

- A. Hot-Mix Asphalt: Use plant-mixed, hot-laid asphalt aggregate mixtures complying with the KYTC Standard Specifications as indicated on the plans.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

- A. Verify that subgrade is dry and in suitable condition to begin paving.
- B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
  - 1. Proof rolling to be performed in presence of Architect or Construction Manager.

2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, Construction Manager, or Geotechnical Engineer, and replace with compacted backfill or fill as directed.
- C. Proceed with paving only after unsatisfactory conditions have been corrected.
- D. Verify that utilities, traffic loop detectors, and other items requiring a cut and installation beneath the asphalt surface have been completed and that asphalt surface has been repaired flush with adjacent asphalt prior to beginning installation of asphalt.

### 3.2 PATCHING

- A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove all soft or unsatisfactory material. Recompact subgrade and any existing unbound-aggregate base course to form new subgrade.
- B. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting against new, hot-mix asphalt paving at a rate of 0.05 to 0.15 gal./sq. yd..
  1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
  2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
- C. Patching: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

### 3.3 REPAIRS

- A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch in existing pavements.
  1. Install leveling wedges in compacted lifts not exceeding 3 inches thick.
- B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of 1/2 inch.
  1. Clean cracks and joints in existing hot-mix asphalt pavement.
  2. Use emulsified-asphalt slurry to seal cracks and joints less than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.
  3. Use hot-applied joint sealant to seal cracks and joints more than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.

### 3.4 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

- B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.
  - 1. Mix herbicide with prime coat if formulated by manufacturer for that purpose.
- C. Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.15 to 0.50 gal./sq. yd.. Apply enough material to penetrate and seal but not flood surface. Allow prime coat to cure.
  - 1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
  - 2. Protect primed substrate from damage until ready to receive paving.
- D. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd..
  - 1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
  - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

### 3.5 PAVING GEOTEXTILE INSTALLATION

- A. Place paving geotextile promptly according to manufacturer's written instructions. Broom or roll geotextile smooth and free of wrinkles and folds. Overlap longitudinal joints 4 inches and transverse joints 6 inches.
  - 1. Protect paving geotextile from traffic and other damage and place next portion of the pavement section the same day.

### 3.6 HOT-MIX ASPHALT PLACING

- A. Asphalt shall be placed in accordance with the KYTC Standard Specifications and as indicated on the plans.
- B. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
  - 1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
  - 2. Place hot-mix asphalt surface course in single lift.
  - 3. Spread mix at minimum temperatures as per KYTC Standard Specifications.
  - 4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
  - 5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
- C. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of asphalt base course before placing asphalt surface course.
- D. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

### 3.7 JOINTS

- A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
1. Clean contact surfaces and apply tack coat to joints.
  2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
  3. Offset transverse joints, in successive courses, a minimum of 24 inches.
  4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints Per KYTC standards.
  5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
  6. Compact asphalt at joints to a density within 2 percent of specified course density.

### 3.8 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.
1. Complete compaction within temperature specifications as set in KYTC Standard Specifications.
- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
1. Average Density: 96 percent of reference laboratory density according to ASTM D 6927, but not less than 94 percent nor greater than 100 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
- F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

### 3.9 INSTALLATION TOLERANCES

- A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
  - 1. Base Course: Plus or minus 1/2 inch (total of all combined base courses).
  - 2. Surface Course: Plus 1/4 inch, no minus.
  - 3. Total Thickness: Where total thickness is of asphalt material is 3" or less, total pavement thickness is to be plus or minus 1/4 inch.
- B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
  - 1. Base Course: 1/4 inch.
  - 2. Surface Course: 1/8 inch.
  - 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

### 3.10 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.
- B. Allow paving to age per manufacturers recommendations before starting pavement marking.
- C. Sweep and clean surface to eliminate loose material and dust.
- D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply per KYTC 713 Specifications to a minimum wet film thickness of 20 mils.

### 3.11 WHEEL STOPS

- A. Securely attach wheel stops to pavement with not less than two galvanized-steel dowels embedded at one-quarter to one-third points. Securely install dowels a minimum of 7 inches into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

### 3.12 FIELD QUALITY CONTROL

- A. Testing Agency: Owner is to engage a qualified testing agency to perform tests and inspections.
- B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

- C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
- D. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979.
  - 1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
  - 2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
    - a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than 3 cores taken.
    - b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
- E. Replace and compact hot-mix asphalt where core tests were taken.
- F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

### 3.13 DISPOSAL

- A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.
  - 1. Do not allow milled materials to accumulate on-site.

**END OF SECTION 321216**

**SECTION 321313 - CONCRETE PAVING****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

**1.2 SUMMARY**

- A. This Section includes exterior cement concrete pavement for the following:
  - 1. Driveways and roadways.
  - 2. Parking lots.
  - 3. Curbs and gutters.
  - 4. Walkways.
- B. Related Sections include the following:
  - 1. Division 03 Section "Cast-in-Place Concrete" for general building applications of concrete.
  - 2. Division 31 Section "Earth Moving" for subgrade preparation, grading, and subbase course.

**1.3 DEFINITIONS**

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

**1.4 SUBMITTALS**

- A. Design Mixtures: For each concrete pavement mixture. Include alternate mixture designs when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
- B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:
  - 1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.
- C. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:
  - 1. Cementitious materials.
  - 2. Admixtures.
  - 3. Curing compounds.

4. Applied finish materials.

D. Jointing Plan

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.
  1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."
- B. Testing Agency Qualifications: An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.
  1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.
- C. ACI Publications:
  1. Comply with ACI 301, "Specification for Structural Concrete," unless modified by requirements in the Contract Documents.
  2. Comply with ACI 330, "Guide for Design and Construction of Concrete Parking Lot" unless modified by requirements in the Contract Documents.
  3. Comply with ACI 325, "Design of Jointed Concrete Pavements for Streets and Local Roads" unless modified by requirements in the Contract Documents.
- D. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.
- E. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."
  1. Before submitting design mixtures, review concrete pavement mixture design and examine procedures for ensuring quality of concrete materials and concrete pavement construction practices. Require representatives, including the following, of each entity directly concerned with concrete pavement, to attend conference:
    - a. Contractor's superintendent.
    - b. Independent testing agency responsible for concrete design mixtures.
    - c. Ready-mix concrete producer.
    - d. Concrete pavement subcontractor.

1.6 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

**PART 2 - PRODUCTS****2.1 MANUFACTURERS**

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
  - 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.

**2.2 FORMS**

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
  - 1. Use flexible or curved forms for curves with a radius 100 feet or less.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

**2.3 STEEL REINFORCEMENT**

- A. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.
- B. Epoxy-Coated Welded Wire Fabric: ASTM A 884/A 884M, Class A, plain steel.
- C. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A 615/A 615M, Grade 60 deformed bars.
- D. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M; with ASTM A 615/A 615M, Grade 60 deformed bars.
- E. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60, deformed bars; assembled with clips.
- F. Epoxy-Coated Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60, plain steel bars.
- G. Tie Bars: ASTM A 615/A 615M, Grade 60, deformed.
- H. Hook Bolts: ASTM A 307, Grade A, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against pavement form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.
- I. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
  2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.
- J. Epoxy Repair Coating: Liquid two-part epoxy repair coating, compatible with epoxy coating on reinforcement.
- K. Zinc Repair Material: ASTM A 780.

## 2.4 CONCRETE MATERIALS

- A. Cementitious Material: Use one of the following cementitious materials, of the same type, brand, and source throughout the Project:
1. Portland Cement: ASTM C 150, Type I., gray. Supplement with the following:
    - a. Fly Ash: ASTM C 618, Class F.
    - b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
- B. Normal-Weight Aggregates: ASTM C 33, Class 4S coarse aggregate, uniformly graded. Provide aggregates from a single source with documented service record data of at least 10 years' satisfactory service in similar pavement applications and service conditions using similar aggregates and cementitious materials.
1. Maximum Coarse-Aggregate Size: 1 inch nominal.
  2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- C. Water: ASTM C 94/C 94M.
- D. Air-Entraining Admixture: ASTM C 260.
- E. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material when steel reinforcement is called out in exterior installations.
1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
  2. Retarding Admixture: ASTM C 494/C 494M, Type B.
  3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
  4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
  5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
  6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

## 2.5 FIBER REINFORCEMENT

- A. Synthetic Fiber: Monofilament polypropylene fibers engineered and designed for use in concrete pavement, complying with ASTM C 1116, Type III, 1/2 to 1-1/2 inches long.

## 2.6 CURING MATERIALS

- A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. Dry, delivered pre-wetted and soaked.

- B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Potable.
- D. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.
- E. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B.

## 2.7 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM 1752 Vinyl full depth, with joint sealant.

## 2.8 CONCRETE MIXTURES

- A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.
  - 1. Use a qualified independent testing agency for preparing and reporting proposed concrete mixture designs for the trial batch method.
- B. Proportion mixtures to provide normal-weight concrete with the following properties:
  - 1. Compressive Strength (28 Days): 4000 psi, unless otherwise indicated on the drawings.
  - 2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.
  - 3. Slump Limit: 3 inches, or up to 5 inches with the use of a water-reducing chemical admixture.
- C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
  - 1. Air Content: 6 percent plus or minus 1.5 percent for 1-inch nominal maximum aggregate size.
- D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
  - 1. Use water-reducing admixture in concrete, as required, for placement and workability.
  - 2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
- F. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements and as follows:
  - 1. Fly Ash or Pozzolan: 25 percent.
  - 2. Ground Granulated Blast-Furnace Slag: 50 percent.
  - 3. Combined Fly Ash or Pozzolan, and Ground Granulated Blast-Furnace Slag: 50 percent, with fly ash or pozzolan not exceeding 25 percent.
- G. Synthetic Fiber: Uniformly disperse in concrete mix at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd..

## 2.9 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.
  - 1. When air temperature is between 85 deg F and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
- B. Proof-roll prepared subbase surface below concrete pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades
  - 1. Proof rolling to be performed in presence of Architect or Construction Manager.
  - 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, Construction Manager, or Geotechnical Engineer, and replace with compacted backfill or fill as directed.
- C. Proceed with concrete pavement operations only after nonconforming conditions have been corrected and subgrade is ready to receive pavement.

### 3.2 PREPARATION

- A. Remove loose material from compacted subbase surface immediately before placing concrete.

### 3.3 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

### 3.4 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain 2" minimum cover to reinforcement.

- D. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
- E. Epoxy-Coated Reinforcement: Use epoxy-coated steel wire ties to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963/D 3963M.
- F. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap of adjacent mats.

### 3.5 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated.
  - 1. When joining existing pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour unless pavement terminates at isolation joints.
  - 1. Continue steel reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of pavement strips, or through locations of intended contraction or isolation joints, unless otherwise indicated.
  - 2. Provide tie bars at sides of pavement strips where indicated.
  - 3. Doweled Joints: Install dowel bars and support assemblies at joints where indicated, or when construction joint will experience heavy truck traffic. Lubricate or asphalt-coat one-half of dowel length to prevent concrete bonding to one side of joint. Dowels to be epoxy coated and sized per ACI 330.
- C. Isolation (expansion) Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
  - 1. Locate expansion joints at intervals of not more than 30 feet, unless otherwise indicated.
  - 2. Extend joint fillers full width and depth of joint.
  - 3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
  - 4. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
  - 5. Protect top edge of joint filler during concrete placement with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
  - 6. Apply joint sealant / caulk.
  - 7. Doweled Joints: Install dowel bars and support assemblies at joints where indicated, or when construction joint will experience heavy truck traffic. Lubricate or asphalt-coat one-half of dowel length to prevent concrete bonding to one side of joint. Dowels to be epoxy coated and sized per ACI 330.

- D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. For thickness 5 inches or less construct contraction joints for a depth equal to at least one-third of the concrete thickness, for thickness greater than 5 inches construct contraction joints for a depth equal to at least one-quarter of the concrete thickness, as follows or match jointing of existing adjacent concrete pavement:
1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.
  2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
  3. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated, or when construction joint will experience heavy truck traffic . Lubricate or asphalt-coat one-half of dowel length to prevent concrete bonding to one side of joint. Dowels to be epoxy coated and sized per ACI 330.
- E. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

### 3.6 CONCRETE PLACEMENT

- A. Inspection: Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast in. Notify other trades to permit installation of their work.
- B. Remove snow, ice, or frost from subbase surface and reinforcement before placing concrete. Do not place concrete on frozen surfaces.
- C. Moisten subbase to provide a uniform dampened condition at time concrete is placed if plastic shrinkage cracking is of concern.
- D. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- E. Comply with ACI 301 and ASTM C94, requirements for measuring, mixing, transporting, and placing concrete.
- F. A one time add of water to concrete during delivery or at Project site is permitted but the water to cementitious material ratio must not be violated.
- G. Do not add water to fresh concrete after testing.
- H. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- I. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms.

Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.

- J. Screed pavement surfaces with a straightedge and strike off.
- K. Commence initial floating using bull floats or darbies to impart an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
- L. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not approved, remove and replace with formed concrete.
- M. Slip-Form Pavers: When automatic machine placement is used for pavement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce pavement to required thickness, lines, grades, finish, and jointing as required for formed pavement.
  - 1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of paver machine during operations.
- N. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.
- O. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
  - 1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
  - 2. Do not use frozen materials or materials containing ice or snow.
  - 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mix designs.
- P. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
  - 1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
  - 2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
  - 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

### 3.7 FLOAT FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven

floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.

### 3.8 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.
- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:
  1. Moist Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
    - a. Water.
    - b. Continuous water-fog spray.
    - c. Absorptive cover, water saturated prior to placement and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
  2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
  3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

### 3.9 TOLERANCES

- A. Comply with tolerances of ACI 117 and as follows:
  1. Elevation: 1/4 inch.
  2. Thickness: Plus 3/8 inch, minus 1/4 inch.
  3. Surface: Gap below 10-foot- long, unlevelled straightedge not to exceed 1/4 inch.
  4. Lateral Alignment and Spacing of Tie Bars and Dowels: 1 inch.
  5. Vertical Alignment of Tie Bars and Dowels: 1/4 inch.
  6. Alignment of Tie-Bar End Relative to Line Perpendicular to Pavement Edge: 1/2 inch.

7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Pavement Edge: Length of dowel 1/4 inch per 12 inches.
8. Joint Spacing: 3 inches.
9. Contraction Joint Depth: Plus 1/4 inch, no minus.
10. Joint Width: Plus 1/8 inch, no minus.

### 3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
  1. Testing Frequency: Obtain at least 1 composite sample for each 5000 sq. ft. or fraction thereof of each concrete mix placed each day.
    - a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
  2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.
  3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
  4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
  5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
  6. Compressive-Strength Tests: ASTM C 39/C 39M; test 1 specimen at 7 days and 2 specimens at 28 days.
    - a. A compressive-strength test shall be the average compressive strength from 2 specimens obtained from same composite sample and tested at 28 days.
- C. Strength of each concrete mix will be satisfactory if average of any 3 consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
- D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
- E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
- F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

- G. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.
- H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

### 3.11 REPAIRS AND PROTECTION

- A. Remove and replace concrete pavement that is broken, damaged, or defective or that does not comply with requirements in this Section.
- B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to pavement with epoxy adhesive.
- C. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

**END OF SECTION 321313**

## **SECTION 328400**

### **PLANTING IRRIGATION**

#### **PART 1      GENERAL**

##### **1.01      RELATED DOCUMENTS**

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

##### **1.02      SUMMARY**

A. Scope of Work:

1. Furnish all labor, materials and equipment for the proper installation of an irrigation system to service all lawn and planted areas. This includes irrigation trenching, tunneling and digging; and providing laying and installing valve(s), control valves, sprinklers, heads, wiring, sleeves under paving, and associated equipment in areas designated on the Drawings.
2. Obtaining and paying for permits, fees, inspections, and tests required for the installation of the system.

B. Related Work:

1. Section 329200 – Turf and Grasses
2. Section 329300 – Plants

##### **1.03      DEFINITIONS**

A. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.

B. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.

C. Irrigation Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.

D. The following are industry abbreviations for plastic materials:

1. PE: Polyethylene plastic.
2. PP: Polypropylene plastic.
3. PVC: Polyvinyl chloride plastic.

##### **1.04      PERFORMANCE REQUIREMENTS**

A. Location of Sprinklers and Specialties: Due to the scale of the Drawing, design locations are approximate. It is not possible to indicate all offsets, fittings, etc., which may be required. Carefully investigate the conditions affecting all of the work and plan accordingly. Make minor adjustments necessary to avoid

plantings and obstructions such as signs and light standards. Maintain 100 percent irrigation coverage of areas indicated.

B. The irrigation plans are drawn diagrammatically. Do not install the irrigation system as shown on the Drawings when it is obvious in the field that obstructions, grade differences, utility conflicts, planting conflicts, drainage problems or discrepancies in dimensions exist that might not have been considered in engineering. Bring such obstructions or differences to the attentions of the Owner's Representative. In the event this notification is not given, the Contractor shall assume full responsibility for any revision necessary.

## 1.05

### SUBMITTALS

A. Product Data: Submit manufacturer's technical data of all products showing manufacturer's name, part names, and catalog numbers.

B. Contractor's qualifications: Submit references for three previous projects of similar size and scope. References shall include project location and client contact name and telephone number.

C. As-built drawings: Upon completion of the system prior to final acceptance. Plans shall be clearly and neatly drawn.

1. Plan shall indicate actual installation.
2. Indicate horizontal and vertical locations, referenced to permanent surface features.
3. Indicate exact vertical and horizontal locations of ends of all sleeves.
4. Indicate field changes of dimensions and detail of the following items:
  - a. Connection to supply line
  - b. Connection to electrical power
  - c. Controller location
  - d. Control wires
  - e. Gate valves
  - f. Routing of mainline and lateral lines
  - g. Sizes of mainline and lateral lines
  - h. Valve locations
  - i. Control valve numbering related to station numbering on controller
  - j. Sleeve locations
  - k. Other related equipment

D. Operation and Maintenance Manual: Prior to the final acceptance of the irrigation system, furnish an operation and maintenance manual for use by the Owner. The manual shall contain complete enlarged drawings, diagrams and spare parts lists of all equipment installed showing manufacturer's name and address. In addition, the manual shall contain the following:

1. Contractor's name, address and phone number
2. Copies of equipment warranties and certificates
3. List of equipment with names, addresses and telephone numbers of all local manufacturers' representatives
4. Complete operating and maintenance instructions in sufficient

detail to permit operating personnel to understand, operate and maintain all equipment. Methodologies for draining system prior to winter must be explained in detail.

- E. Maintenance Material: Supply the following tools to the Owner:
1. Three (3) sets of specialized tools required for removing, disassembling and adjusting each type of sprinkler, valve or other equipment supplied on this project.
  2. Two (2) keys for each type of equipment enclosure.
  3. Two (2) keys for each type of automatic controller.
  4. Two (2) quick-coupler keys and matching hose swivels for each type of quick coupling valve installed.
  5. Two (2) five foot valve keys for operation of gate valves.

#### 1.06 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide irrigation system as a complete unit produced by a single acceptable manufacturer, including heads, valves, controls and accessories.

B. Codes and Standards: All materials and installations shall conform to applicable local, state, federal codes, and irrigation industry standards. Comply with the requirements of the utility supplying water and authorities having jurisdiction for preventing backflow and back siphonage.

C. Contractor Qualifications: Irrigation work shall be performed by a single firm, acceptable to the Owner's Representative and the Landscape Architect, specializing in irrigation design and installation. Irrigation system designer and installer shall have a minimum of five years experience with design and installation of similar sized irrigation systems. It is preferred that the irrigation contractor holds a CIC, CID, or CLIA certification from the irrigation association.

D. Substitutions: No substitutions from the initial plan will be permitted without review and approval by the Owner's Representative and Landscape Architect. In the event the Contractor desires to make substitutions of materials, sufficient descriptive literature and material samples must be furnished to establish the material as an equal substitute. In addition, the Contractor must state the reasons for desiring to substitute materials. Lastly, the proposed material substitution must equal or exceed the original design intent as it pertains to water conservation and sustainable design if applicable. Submit this request and information to both the Owner's Representative and the Landscape Architect.

E. Approval and Selection of Materials and Work: The selection of all materials and the execution of all operations required under this specification is subject to the approval of the Owner's Representative and Landscape Architect, who have the right to reject any and all materials and any and all Work which, in their opinion, does not meet the requirements of the Contract Documents at any stage of the operations. Remove rejected Work and or materials from Project Site and replace promptly.

1. Obtain signed acceptance by Owner's Representative of installed pipe, fittings, valves and wiring prior to backfilling of trenches.

F. Workmanship: Install materials and equipment in a neat and professional manner following manufacturer's recommendations.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

A. The Owner's Representative shall designate a specific area in which all material to be used on the project shall be stored when not in use. Provision of these area(s) is for the purpose of keeping the property neat and orderly, and in no way waives any requirements of the Contractor to protect equipment and materials from damage by the elements or from theft or vandalism.

B. The Contractor shall be responsible for correct procedures in loading, unloading, stacking, transporting, and handling all materials to be used in the system. The Contractor shall avoid rough handling which could affect the useful life of equipment. All materials shall be handled in accordance with the manufacturer's recommendations on loading, unloading, and storage.

#### 1.08 PROJECT CONDITIONS

A. The Contractor shall locate all utilities, subsurface drainage, and underground construction so that proper precautions may be taken not to disturb or damage any subsurface improvements.

B. The Contractor shall coordinate with the work of other trades and the Owner as required to assure proper and timely installation.

C. The Contractor shall continuously maintain adequate protection of all work from damage and shall protect the Owner's property from injury or loss arising in connection with work on this contract. The Contractor shall take care to avoid damage to any existing buildings, equipment, piping, pipe coverings, electrical systems, sewers, sidewalks, landscaping, grounds, aboveground or underground installations or structures of any kind, and shall be held responsible for any damage that does occur. Damage includes not only mechanical damage, but also from leaks in the irrigation system being installed by the Contractor, whether through negligence or otherwise.

D. The Contractor shall adequately protect adjacent property and shall provide and maintain all passageways, guard fences, lights and other facilities for protection required by the Owner for local conditions.

E. The Contractor shall securely cover all openings into the section of the system being worked upon and components of the system as it is being installed, to prevent obstructions in the pipe and the breakage, misuse, or disfigurement of the equipment.

#### 1.09 COORDINATION

A. Contractor(s) shall coordinate with the work of other trades and the

Owner's Representative as required assuring proper and timely installation.

1.10 CLEANING PREMISES

A. The Contractor shall continuously keep a neat and orderly area in which system is being installed. Disposal of rubbish and waste material resulting from the installation shall be continual.

B. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from sight-exposed interior and exterior surfaces.

C. Broom clean exterior paved surfaces; rake clean other ground surfaces.

D. Upon completion of the system, the Contractor shall remove all excess material and debris from the Owner's property, at the Contractor's expense, resulting from the installation of said system.

**PART 2 PRODUCTS**

2.01 GENERAL

A. All materials used in the system must be new and without flaws or defects of any type and be the best quality available. All materials shall have a minimum three (3) year warranty against material defects or defective workmanship.

2.02 PIPE AND FITTINGS

A. Subject to compliance with requirements, provide products as manufactured by:

1. Crestline
2. Certainteed Corporation
3. Dura
4. Or approved equal

B. PVC Pipe Sleeves and Irrigation Mainline: ASTM D 1785, PVC 1120 compound, Schedule 40.

1. PVC Socket Fittings: ASTM D 2466, Schedule 40.
2. PVC Threaded Fittings: ASTM D 2464, Schedule 80.
3. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.

C. PVC Pipe for Irrigation lateral lines: ASTM D 2241, PVC 1120 compound, SDR 21, rigid, unplasticized PVC, extruded from virgin parent material. Provide pipe homogeneous throughout and free from visible cracks, holes, foreign materials, blisters, wrinkles, and dents.

1. Class 200 PVC

D. PVC pipe fittings: ASTM D2241 schedule 40 PVC molded fittings suitable for solvent weld, slip joint seal, or screwed connections. Fittings made of other

materials are not permitted.

1. Size slip fitting socket taper to permit a dry unsoftened pipe end to be inserted no more than halfway into the socket. Saddle and cross fittings are not permitted.
2. Schedule 80 PVC may be threaded.
3. Use male adapters for plastic to metal connections. Hand tighten male adapters plus one turn with a strap wrench.
4. Use purple primer at all fitting and connections.

E. Piping Joining Materials:

1. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.03 ISOLATION VALVES

- A. Provide all gate valves for isolation purposes, allowing full diameter opening when in full open position.
- B. Manually operated valves shall be the same size as the line.
- C. Valves three (3) inches or smaller shall be brass construction, threaded, and rated for two hundred (200) psi WOG.
- D. Valves four (4) inches or larger shall be cast iron fitted with a rubber ring, slab - type gasket.

2.04 BACKFLOW PREVENTER:

- A. Per local codes. Refer to plumbing drawings for location and stub out.

2.05 ELECTRIC WIRING

A. 120 Volt AC Wiring:

1. 120 volt service to controller shall consist of three wires: one black, one white, and one ground. Electrical service is to be provided by the General Contractor unless otherwise directed by Owner's Representative. It is the Irrigation Contractors responsibility to coordinate the location of electrical service to be provided for controller.
2. Splices in controller wiring shall be waterproof using 3M-DBY wire connectors or approved equal.
3. Provide junction box, flush-mounted and gasketed per code as required.
4. Control Wiring shall be 24 volt solid wire Underwriter's Laboratory (UL) approved for direct burial in ground. Minimum wire size shall be fourteen (14) gauge. All control wiring and wiring connections from the controller to the valves is included in this Contract.

2.06 VALVE BOXES

- A. Valve Access Box: Tapered rib reinforced enclosure of rigid plastic material comprised of polyolefin fibrous components chemically inert and unaffected by moisture, ultra violet light, corrosion and temperature changes. Provide lid of same material, green in color with snap lock cover. AMETEK or approved equal (10" round minimum size) allowed.
  - 1. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3" maximum to 3/4" minimum.

2.07 THRUST BLOCKS

- A. Concrete mix consisting of one part cement, two parts washed sand, and five parts washed gravel. Provide 3/4-inch x 24-inch rebars or 2-foot metal drive post.

2.08 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with requirements, provide the remaining products as manufactured by: The Rainbird Corporation.

2.09 VALVES:

- A. Quick coupling valves: Used for manual access to the pressurized mainline so that a hose can be attached and used for hand watering. Quick coupling valves shall be constructed of brass with a spring loaded seal that will keep the valve in a closed position until the key is inserted into the valve. Valve shall also have a hinged aluminum cap to prevent any debris getting into the internal mechanism of the valve. Quick coupling valves shall be installed on a triple elbow swing joint.
  - 1. Quick coupling valves keys shall be of the single lug variety. Attached to the key will be a hose swivel adapter sized to the hose commonly used on the project. Irrigation Contractor to contact Owner's Representative to determine hose type. Key and swivel shall both be constructed of brass.
- B. Control valves: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.

2.10 SPRINKLER HEADS:

- A. Manufacturer's standard unit designed to provide uniform coverage over entire area of spray shown on drawings at available water pressure, as follows:
  - 1. Shrubbery: Fixed pattern, with screw-type flow adjustment.
  - 2. Pop-Up Spray: Fixed pattern, with screw-type adjustment and stainless steel retraction spring.
  - 3. Pop-up Rotary Spray: Gear drive, full circle and adjustable part circle type.

2.11 AUTOMATIC RAIN SHUT OFF DEVICES

- A. Provide rain shut off device that shall be set to shut off the system in the event of an approximate accumulation of 1/4" of rainfall. The rain shut off

device shall reset itself within a reasonable amount of time to allow the system to activate at its regular programmed run time.

B. The rain shut off device shall be mounted a minimum of 10' above grade in a location unobstructed by typical rainfall for that location, and protected against vandalism. Wiring shall be installed in heavy wall rigid steel conduit and fastened securely to structures with stainless steel fasteners.

C. Provide soil moisture sensors.

## 2.12 AUTOMATIC CONTROL SYSTEM

A. As shown on the drawings.

## 2.13 MISCELLANEOUS SYSTEM COMPONENTS

A. Provide risers, reducers, couplings, adapters, fittings, and ancillary equipment as necessary to complete the irrigation system.

B. Provide equipment for winterizing the system.

C. Per University Standards, furnish and install:

1. Grounding rods every 500-600 feet at terminal ends of wire. The top of the grounding rods should be in a 10 inch round box. The grounding rods are to be 6-8 feet in length.
2. Surge protectors every 500-600 feet or at each zone valve. The surge protectors should be put in an existing 10" box or put in a separate box.
3. Tracer wires for all mains and laterals in the irrigation system.

D. Per University Standards, provide GPS coordinates and elevation for each end of irrigation sleeves.

## **PART 3 EXECUTION**

### 3.01 PREPARATION

A. Sleeves and conduits: Provide sleeves and conduits as indicated and where control wires and pipes pass under paving or through walls. Install as indicated on Drawings. Coordinate installation of sleeves with the General Contractor prior to the start of pavement operations.

1. Pipe and control wiring under walks, roads and other hard surfaces shall be installed in sleeves of adequate size.

B. Coordinate and schedule all Work with Owner's Representative, General Construction Contractor, and / or Landscape Contractor, as appropriate.

C. Contractor(s) shall be responsible for coordination with the planting design and actual field conditions to insure appropriate water quantities for specific plant materials and site conditions.

3.02

INSPECTION

A. Examine final grades and installation conditions. Irrigation system work shall not commence until prior completion and approval by Landscape Architect of finish grading, staking of groundcover beds and staking of landscape edging.

B. Utilities: Do not start irrigation work until all utility work is completed in the area. Flag all existing underground utilities prior to trenching and / or boring operations. Obtain locations of any new utilities from the Owner's Representative and / or the General Contractor. Irrigation Contractor is solely responsible for contacting the utility locating service(s) and Owner's Representative (with 48 hours minimum notification) and locating on - site utilities in advance of installation.

C. Sleeves and conduits: Verify that all installed sleeves and conduits are undisturbed and are free of defects or errors introduced by the work of other sections.

D. Water meter/Water pressure: Test and verify that installation of irrigation water meter by others has generated level of water pressure specified on the Drawings. Report any discrepancies in water pressure to Owner's Representative prior to installation of the system.

E. Mechanical Room: Inspect and verify acceptability of room in building designated to receive automatic controller(s).

F. Point of Connection: Verify that the point of connection to be provided under other contract is correctly sized, located and installed as noted on the Drawings.

3.03

TRENCHING AND BACKFILLING

A. Excavate straight and true with bottom uniformly sloped to low points.

B. Protect existing lawns and plantings. Remove and replant as necessary to complete the installation. Replace damaged lawn areas and plants with new to match size and type of the existing.

C. Excavate trenches to a depth of 3" below invert of pipe, unless otherwise indicated.

D. Provide a 12" minimum cover over top of installed piping or deeper as needed to meet local requirements. Refer to irrigation details.

E. Backfill with clean material from excavation. Remove organic material as well as rocks and debris larger than 1" diameter. Place acceptable backfill material in 6" lifts, compacting each lift.

1. The contractor shall not crown the backfill on the trench area with the thought that it will eventually settle; this will not be accepted

as a finished job.

F. Provide 1" depth sand under piping, and 3-4" sand above the pipe, then use specified backfill material to fill the remaining trench volume, per University standards.

G. Where trenching is required across existing lawns, uniformly cut strips of sod 6" wider than the trench. Remove sod in rolls of suitable size for handling and keep moistened until replanted.

H. Backfill trench to within 6" of finished grade. Continue fill with acceptable topsoil and compact to bring sod even with finished lawn elevations.

I. Existing pavements are not to be cut. Run pipes and conduit underneath pavements through sleeve(s) provided. Obtain approval of all proposed trenching from the Owner's Representative prior to commencing that portion of the work.

### 3.04

#### INSTALLATION

A. General:

1. Unless otherwise indicated, comply with requirements of Uniform Plumbing Code and Manufacturer's Specifications.
2. Install piping and wiring in sleeves under walks, roadways, and paving.
3. Install all equipment per manufacturer's recommendations.

B. Connection to Main: Connect to supply and install backflow preventer in accordance with manufacturer's recommendations and all federal, state and local codes.

C. Maintain uninterrupted water service during normal working hours. Arrange for manual water shut-off valve(s) with Owner's Representative.

D. Circuit Valves: Install in valve box, arranged for easy adjustment and removal.

1. Provide union on downstream side.
2. Adjust automatic control valves to provide flow rate of rated operating pressure required for each circuit.

E. Piping: Lay pipe on solid subbase, uniformly sloped without humps or depressions.

1. Install plastic pipe in accordance with manufacturer's installation instructions. Provide for thermal expansion and contraction.
2. Saw cut plastic pipe. Use a square-in-sawing vice, to ensure a square cut. Remove burrs and shavings at cut ends prior to installation.
3. Make plastic to plastic joints with solvent weld joints or slip seal joints. Use only solvent recommended by the pipe manufacturer. Install plastic pipe fittings in accordance with pipe manufacturer's instructions. Contractor shall make arrangements with pipe manufacturer for all necessary field assistance.
4. Make plastic to metal joints with plastic male adapters.

5. For circuit piping, slope to drain valve at least 1/2" in 10' of run.
6. Install PVC pipe in dry weather when temperature is above 40 degrees F (4 degrees C) in strict accordance with manufacturer's specifications and/or codes. Allow joints to cure at least 24 hours at temperature above 40 degrees F (4 degrees C) before testing, unless otherwise recommended by manufacturer.
7. Install at uniform slope of 0.5% minimum down toward drain valves.
8. Flush dirt and debris from piping before installing sprinklers and other devices.

F. Thrust Blocks:

1. Provide concrete thrust blocks of adequate size on the thrust side along main supply line at anywhere over a 45-degree angle, for 2" and larger mainline only.
2. Thrust blocks are to be made of concrete and placed between the fittings and the trench wall. The concrete shall be fresh and extend to undisturbed (freshly cut) trench wall. The concrete mix will be a dry or stiff mix (minimum amount/water). Provide (2) 3/4" x 24" rebars per thrust block or (1) 2' metal drive post. Drive rebars or drive post flush with top of thrust block. The thrust block shall be a minimum of 12" wide x 12" long x 4" thick.
3. On the smaller sizes of pipe, up to and including 4" pipe, the construction of horizontal thrust blocks requires only the simplest of forms; the stiff concrete is shaped to block a wedge with its widest part against solid trench wall. Larger blocks require some form construction at the sides and top to achieve proper bearing areas with a minimum of concrete.
4. If the ground is too soft to provide proper support for the thrust block, the Contractor will furnish and install clams and tie rods for the retainment of the fitting.

G. Sprinkler Heads: Flush circuit lines with full head of water and install heads after hydrostatic test is completed.

1. Locate part-circle heads to maintain a minimum distance of 4" from walls and 2" from other boundaries, unless otherwise indicated.
2. Install at manufacturers recommended heights.

H. Dielectric Protection: Use dielectric fittings at connection where pipes of dissimilar metal are joined.

I. Control Lines:

1. All control lines shall be installed in a neat and orderly fashion and may be installed either in the main and lateral trenching or in their own separate trench. The lines shall be bundled together and taped every 5'.
2. Install wiring with loops at control valves and controllers, at intervals not greater than 100 feet, and changes in direction to allow for expansion.
3. Keep wire splices to a minimum and provide ten (10) inch round valve box at each splice location.

J. Controller: Install new controller in mechanical room as indicated on Drawing.

K. Valve Boxes: All valves are to be housed in valve boxes. All valve boxes shall be installed so the top of said structure is at finished grade. Locate in shrub beds wherever possible. Fill bottom of valve boxes with a minimum of 2" deep gravel.

L. Quick Couplers: Install in locations indicated on the drawings. Install per manufacturer's recommendations in valve boxes.

### 3.05 TESTING

A. Notify the Owner's Representative when all testing will be conducted. Conduct tests in presence of Owner's Representative and/or other approved representative.

B. Test water piping and valves, before backfilling trenches, to a hydrostatic pressure of not less than manufacturer's recommended minimum. Piping may be tested in sections to expedite work. Remove and repair piping, connections, and valves which do not pass hydrostatic testing.

C. Operational Testing:

1. Perform operational testing after hydrostatic testing is completed, backfill is in place, and sprinkler heads adjusted to final position.
2. Demonstrate to Owner's Representative and maintenance personnel that system meets coverage requirements and that automatic controls function properly.
3. Coverage requirements are based on operation of one circuit at a time.

D. Adjustment: Adjust sprinklers after installation for proper and adequate distribution of the water over the coverage pattern. Adjust for the proper arc of coverage.

1. Tighten nozzles on spray type sprinklers after installation. Adjust sprinkler adjusting screw on lateral line or circuit as required for proper radius. Interchange nozzles patterns as directed by the Landscape Architect, to give the best arc of coverage.
2. Make minor adjustments as necessary to avoid plantings and other obstructions.
3. Demonstrate to the Owner's Representative that system meets watering requirements.

### 3.06 ACCEPTANCE

A. Test and demonstrate to the Landscape Architect and Owner the satisfactory operation of the system free of leaks and defects.

B. Instruct Owner's designated personnel in the operation of the system, including adjustment of sprinklers, valves, controller(s), pump controls,

winterization and start-up procedures.

C. Upon acceptance the Owner will assume operation of the system.

3.07 SERVICE

A. Return to the site the subsequent fall season and demonstrate to the Owner the proper procedures to winterize the system. Drain all water from the system with compressed air.

B. Return to the site during the subsequent spring season and demonstrate to the Owner the proper procedures for the system start-up.

3.08 WARRANTY

A. For a period of one (1) year from the date of Final Acceptance by the Owner, the Contractor(s) shall unconditionally warrant all material, equipment, design, and workmanship to be free from inherent defects, and warrants against any malfunction caused thereby. Contractor(s) shall, at his own expense, cause all defects discovered during this period to be removed, repaired, and/or replaced to the complete satisfaction of the Owner.

B. All irrigation system components shall be supplied by authorized distributors responsible for manufacturer's warranty and service for equipment installed at the project location.

C. Repair unsatisfactory conditions promptly at no cost to the Owner.

D. Emergency repairs may be made by the Owner's Representative, General Contractor, or Landscape Contractor, as appropriate, without relieving the Irrigation Contractor of any warranty obligations.

E. Repair settling of backfilled trenches occurring during the warranty period, including restoration of damaged plantings, paving, or improvements resulting from settling of trenches or repair operations.

F. Repair costs may include the cost to restore or replace plant material which dies due to dehydration and the cost of any supplemental watering deemed appropriate by the Owner's Representative.

G. Respond to Owner's Representative's request for repair work within forty-eight (48) working days. If Irrigation Contractor does not respond in this time frame, Owner's Representative may proceed with any necessary repairs at the Irrigation Contractor's expense.

**END OF SECTION 328400**

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## **SECTION 329113**

### **SOIL PREPARATION**

#### **PART 1 - GENERAL**

##### **0.1 RELATED DOCUMENTS**

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

##### **0.2 SUMMARY**

- A. Section includes planting soils specified by composition of the mixes, testing and placement.
- B. Related Requirements:
  - 1. Section 329200 "Turf and Grasses" for placing planting soil for turf and grasses.
  - 2. Section 329300 "Plants" for placing planting soil for plantings.

##### **0.3 UNIT PRICES**

- A. Work of this Section is affected by unit prices specified in Section 012200 "Unit Prices."

##### **0.4 DEFINITIONS**

- A. AAPFCO: Association of American Plant Food Control Officials.
- B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or unamended soil as indicated.
- C. CEC: Cation exchange capacity.
- D. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.
- E. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.
- F. Imported Soil: Soil that is transported to Project site for use.
- G. Layered Soil Assembly: A designed series of planting soils, layered on each other, that together produce an environment for plant growth.

- H. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.
- I. NAPT: North American Proficiency Testing Program. An SSSA program to assist soil-, plant-, and water-testing laboratories through interlaboratory sample exchanges and statistical evaluation of analytical data.
- J. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."
- K. Planting imported topsoil, or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- L. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.
- M. SSSA: Soil Science Society of America.
- N. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
- O. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.
- P. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.
- Q. USCC: U.S. Composting Council.

#### 0.5 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

#### 0.6 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Include test data substantiating that products comply with requirements.
  - 2. Include sieve analyses for aggregate materials.
  - 3. Material Certificates: For each type of imported soil, soil amendment and fertilizer before delivery to the site, according to the following:
    - a. Manufacturer's qualified testing agency's certified analysis of standard products.

- B. Samples: For each bulk-supplied material, 1-quart (1-L) volume of each in sealed containers labeled with content, source, and date obtained. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of composition, color, and texture.
- C. Sustainable Design Submittals:
  - 1. Credit MR 5: Product Data for regional materials indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.

#### 0.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For each testing agency.
- B. Preconstruction Test Reports: For preconstruction soil analyses specified in "Preconstruction Testing" Article.
- C. Field quality-control reports.

#### 0.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.

#### 0.9 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction soil analyses on imported topsoil.
- B. Preconstruction Soil Analyses: For each unamended soil type, perform testing on soil samples and furnish soil analysis and a written report containing soil-amendment and fertilizer recommendations by a qualified testing agency performing the testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.
  - 1. Have testing agency identify and label samples and test reports according to sample collection and labeling requirements.

#### 0.10 SOIL-SAMPLING REQUIREMENTS

- A. General: Extract soil samples according to requirements in this article.
- B. Sample Collection and Labeling: Have samples taken and labeled by Contractor under the following direction:

1. Number and Location of Samples: Minimum of three representative samples for topsoil to be used or amended for landscaping purposes.
2. Procedures and Depth of Samples: According to USDA-NRCS's "Field Book for Describing and Sampling Soils.
3. Labeling: Label each sample with the date, location keyed to a site plan or other location system, visible soil condition, and sampling depth.

#### 0.11 TESTING REQUIREMENTS

- A. General: Perform tests on soil samples according to requirements in this article.
- B. Physical Testing:
  1. Soil Texture: Soil-particle, size-distribution analysis by one of the following methods according to SSSA's "Methods of Soil Analysis - Part 1-Physical and Mineralogical Methods":
    - a. Sieving Method: Report sand-gradation percentages for very coarse, coarse, medium, fine, and very fine sand; and fragment-gradation (gravel) percentages for fine, medium, and coarse fragments; according to USDA sand and fragment sizes.
    - b. Hydrometer Method: Report percentages of sand, silt, and clay.
- C. Fertility Testing: Soil-fertility analysis according to standard laboratory protocol of SSSA NAPT NCR-13, including the following:
  1. Percentage of organic matter.
  2. CEC, calcium percent of CEC, and magnesium percent of CEC.
  3. Soil reaction (acidity/alkalinity pH value).
  4. Buffered acidity or alkalinity.
  5. Nitrogen ppm.
  6. Phosphorous ppm.
  7. Potassium ppm.
  8. Manganese ppm.
  9. Manganese-availability ppm.
  10. Zinc ppm.
  11. Zinc availability ppm.
  12. Presence and quantities of problem materials including salts and metals cited in the Standard protocol. If such problem materials are present, provide additional recommendations for corrective action.
  13. Other deleterious materials, including their characteristics and content of each.
- D. Organic-Matter Content: Analysis using loss-by-ignition method according to SSSA's "Methods of Soil Analysis - Part 3- Chemical Methods."
- E. Recommendations: Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated to produce satisfactory planting soil suitable for healthy,

viable plants indicated. Include, at a minimum, recommendations for nitrogen, phosphorous, and potassium fertilization, and for micronutrients.

1. Fertilizers and Soil Amendment Rates: State recommendations in weight per 1000 sq. ft. (100 sq. m) for 6-inch (150-mm) depth of soil.
2. Soil Reaction: State the recommended liming rates for raising pH or sulfur for lowering pH according to the buffered acidity or buffered alkalinity in weight per 1000 sq. ft. (100 sq. m) for each 6-inch (150-mm) depth of soil.

#### 0.12 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.
- B. Bulk Materials:
  1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
  2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
  3. Do not move or handle materials when they are wet or frozen.
  4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

#### 0.13 EXAMINATION OF CONDITIONS

- A. All areas to receive Structural Soil shall be inspected by the installing contractor before starting work

### **PART 2 - PRODUCTS**

#### 0.1 PLANTING SOILS SPECIFIED BY COMPOSITION

- A. General: Soil amendments, fertilizers, and rates of application specified in this article are guidelines that may need revision based on testing laboratory's recommendations after preconstruction soil analyses are performed.
- B. Planting-Soil Type A: Imported, naturally formed, unamended topsoil from off-site sources and consisting of loamy soil according to USDA textures.
  1. Sources: Take imported, unamended topsoil from sources that are naturally well-drained sites where topsoil occurs at least 4 inches (100 mm) deep, not from bogs, or marshes; and that do not contain undesirable organisms; disease-causing plant

- pathogens; or obnoxious weeds and invasive plants including, but not limited to, quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and brome grass.
2. Additional Properties of Imported Soil before Amending: Soil reaction of pH 6 to 8 and minimum of 5 percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration.
  3. Unacceptable Properties: Clean soil of the following:
    - a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
    - b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 8 percent by dry weight of the imported soil.
    - c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 2 inches (50 mm) in any dimension.
- C. Planting Soil Type B: Amended Topsoil. Blend imported, approved unamended topsoil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
1. Ratio of Loose Leaf Compost to Soil: 1:4 by volume.
  2. Fertilizers as recommended by the soil test analysis.

## 0.2 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
1. Class: T, with a minimum of 99 percent passing through a No. 8 (2.36-mm) sieve and a minimum of 75 percent passing through a No. 60 (0.25-mm) sieve.
  2. Class: O, with a minimum of 95 percent passing through a No. 8 (2.36-mm) sieve and a minimum of 55 percent passing through a No. 60 (0.25-mm) sieve.
  3. Form: Provide lime in form of ground dolomitic limestone.
- B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 (3.35-mm) sieve and a maximum of 10 percent passing through a No. 40 (0.425-mm) sieve.
- C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
- D. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a No. 50 (0.30-mm) sieve.
- E. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C 33/C 33M.

### 0.3 ORGANIC SOIL AMENDMENTS

- A. Leaf Compost: Well-composted, stable, and weed-free organic matter, humus rich type derived from the decomposition of leaves and ground bark. Texture shall be similar to a shredded peat; pH range of 5.5 to 8, moisture content 35 to 55 percent by weight; soluble salt content of 10 decisiemens/m, maximum; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings.

### 0.4 FERTILIZERS

- A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
  - 1. Composition: 1 lb/1000 sq. ft. (0.5 kg/100 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
  - 2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.
- C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
  - 1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
  - 2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.
- D. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

## **PART 3 - EXECUTION**

### 0.1 GENERAL

- A. Place planting soils and fertilizers according to requirements in other Specification Sections.
- B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.
- C. Proceed with placement only after unsatisfactory conditions have been corrected.

0.2 PLACING APPROVED UNAMENDED TOPSOIL (TYPE A) AND AMENDED TOPSOIL (TYPE B) PLANTING SOILS OVER EXPOSED SUBGRADE

- A. General: Apply approved topsoil and pre-mixed amended topsoil with compost amendments and amendments recommended by the soil tests to areas indicated on the drawings. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Subgrade Preparation: Till subgrade to a minimum depth of 6 inches (150 mm). Remove stones larger than 1-1/2 inches (38 mm) in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
  - 1. Apply approved topsoil and pre-mixed amended topsoil over prepared, loosened subgrade. Mix thoroughly into top 2 inches (50 mm) of the subgrade. Spread remainder of planting soil to depth indicated on the drawings.
  - 2. Lifts: Apply planting soils in lifts not exceeding 8 inches (200 mm) in loose depth for material compacted by compaction equipment, and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.
- C. Compaction: Compact each lift of Type A and Type B planting soil to 75 to 80 percent of maximum Standard Proctor density according to ASTM D 698 and tested in-place.
- D. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly

0.3 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Perform the following tests:
  - 1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D 698. Space tests at no less than one for each 1000 sq. ft. (100 sq. m) of in-place soil or part thereof.
- C. Soil will be considered defective if it does not pass tests.
- D. Prepare test reports.
- E. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

0.4 PROTECTION

- A. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:
  - 1. Storage of construction materials, debris, or excavated material.
  - 2. Parking vehicles or equipment.
  - 3. Vehicle traffic.
  - 4. Foot traffic.
  - 5. Erection of sheds or structures.
  - 6. Impoundment of water.
  - 7. Excavation or other digging unless otherwise indicated.
- B. If planting soil or subgrade is over compacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Architect and replace contaminated planting soil with new planting soil.

0.5 CLEANING

- A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.
- B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.
  - 1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

**END OF SECTION 329113**

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## **SECTION 329200**

### **TURF AND GRASSES**

#### **PART 1 - GENERAL**

##### **0.1 RELATED DOCUMENTS**

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

##### **0.2 SUMMARY**

- A. Section Includes:
  - 1. Sodding.
  - 2. Turf renovation.
- B. Related Requirements:
  - 1. Section 329113 "Soil Preparation" for planting soils and placement of planting soils.
  - 2. Section 329300 "Plants" for trees, shrubs, ground covers, and other plants, as well as border edgings and mow strips.

##### **0.3 DEFINITIONS**

- A. Finish Grade: Elevation of finished surface of planting soil.
- B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 "Soil Preparation" and drawing designations for planting soils.
- E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

##### **0.4 INFORMATIONAL SUBMITTALS**

- A. Qualification Data: For landscape Installer.

- B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
  - 1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.
- C. Product Certificates: For fertilizers, from manufacturer.
- D. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.
- E. Sustainable Design Submittals:
  - 1. Credit MR 5: Product Data for regional materials indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.

#### 0.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf establishment.
  - 1. Experience: Five years' experience in turf installations similar in material and extent to that indicated for this project, and a record of successful landscape establishment, in addition to requirements in Section 014000 "Quality Requirements"
  - 2. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
  - 3. Pesticide Applicator: State licensed, commercial.

#### 0.6 DELIVERY, STORAGE, AND HANDLING

- A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.
- B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.
- C. Bulk Materials:
  - 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
  - 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
  - 3. Accompany each delivery of bulk materials with appropriate certificates.

0.7 FIELD CONDITIONS

- A. Planting Restrictions: Sodding of permanent lawns to occur from March 15 through November 30. Sodding operations at other times shall be only with the approval of the Owner's Representative and at the Contractor's risk.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

**PART 2 - PRODUCTS**

0.1 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.

0.2 TURFGRASS SOD

- A. Turfgrass Sod: Certified, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.
  - 1. Sod shall be well-rooted, containing a growth of not more than 3 percent of other undesirable grass species or weed species. The turf shall be of sufficient density so that no surface soil is visible when mowed to a height of 1.5 inches. The thickness of the soil portion of the sod shall not exceed .60 inch.
- B. Turfgrass Species: Turf-type tall fescue blend (*Festuca arundinacea*), shade tolerant blend.

0.3 FERTILIZERS

- A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
  - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
  - 1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

0.4 PESTICIDES

- A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

### **PART 3 - EXECUTION**

#### **0.1 EXAMINATION**

- A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.
  - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
  - 2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
  - 3. Uniformly moisten excessively dry soil that is not workable or which is dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

#### **0.2 PREPARATION**

- A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
  - 1. Protect grade stakes set by others until directed to remove them.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

#### **0.3 TURF AREA PREPARATION**

- A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation."
- B. Placing Planting Soil: Place planting soil in place over exposed subgrade.

1. Reduce elevation of planting soil to allow for soil thickness of sod.
- C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

#### 0.4 SODDING

- A. Lay sod within 24 hours of harvesting unless a suitable preservation method is accepted by Architect prior to delivery time. Do not lay sod if dormant or if ground is frozen or muddy.
- B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
  1. Lay sod across slopes exceeding 1:3.
  2. Anchor sod on slopes exceeding 1:6 with wood pegs spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.
- C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches (38 mm) below sod.

#### 0.5 TURF RENOVATION

- A. Renovate existing turf where indicated.
- B. Renovate turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
  1. Reestablish turf where settlement or washouts occur or where minor regrading is required.
  2. Install new planting soil as required.
- C. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.
- D. Remove topsoil containing foreign materials, such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.
- E. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.
- F. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.

- G. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches (150 mm).
- H. Apply initial fertilizer required for establishing new turf and mix thoroughly into top 4 inches (100 mm) of existing soil. Install new planting soil to fill low spots and meet finish grades.
- I. Apply sod as required for new turf.
- J. Water newly planted areas and keep moist until new turf is established.

#### 0.6 TURF MAINTENANCE

- A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and mulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
  - 1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
  - 2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
  - 3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
- B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches (100 mm).
  - 1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
  - 2. Water turf with fine spray at a minimum rate of 1 inch (25 mm) per week unless rainfall precipitation is adequate.
- C. Turf Postfertilization: Apply slow-release fertilizer after initial mowing and when grass is dry.
  - 1. Use fertilizer that provides actual nitrogen of at least 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) to turf area.

#### 0.7 SATISFACTORY TURF

- A. Turf installations shall meet the following criteria as determined by Architect:
  - 1. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
- B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

- A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.
- B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

#### 0.9 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.
- C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.
- D. Remove nondegradable erosion-control measures after grass establishment period.

#### 0.10 MAINTENANCE SERVICE

- A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:
  - 1. Sodded Turf: 60 days from date of planting completion.

**END OF SECTION 329200**

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## **SECTION 329300**

### **PLANTS**

#### **PART 1 - GENERAL**

##### **0.1 RELATED DOCUMENTS**

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

##### **0.2 SUMMARY**

- A. Section Includes:
  - 1. Plants.
  - 2. Tree stabilization.
  - 3. Landscape edgings.
  - 4. Mulch.
  - 5. Tree-Watering Devices.
- B. Related Requirements:
  - 1. Section 329113 "Soil Preparation" for imported topsoil and amended planting soil.
  - 2. Section 329200 "Turf and Grasses" for turf (lawn).

##### **0.3 DEFINITIONS**

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.
- C. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.
- D. Finish Grade: Elevation of finished surface of planting soil.
- E. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and

molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

- F. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- G. Planting Area: Areas to be planted.
- H. Planting Soil: Imported soil or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 "Soil Preparation" for drawing designations for planting soils.
- I. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
- J. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.
- K. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.
- L. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

#### 0.4 COORDINATION

- A. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
- B. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

#### 0.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
  - 1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.
  - 2. Tree Sources: Submit proposed sources for all trees within 60 days of award of contract. Provide name and location of nursery, contact person, and telephone number.
  - 3. Tree Holding: Submit proposed temporary tree holding locations between tagging and transport to the Project Site.
- B. Samples for Verification: For each of the following:
  - 1. Organic Mulch: 1-pint (0.5-L) volume of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch.
- C. Sustainable Design Submittals:

1. Credit MR 5: Product Data for regional materials indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each regional material.

#### 0.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.
- B. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
  1. Manufacturer's certified analysis of standard products.
  2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.
- C. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.
- D. Sample Warranty: For special warranty.

#### 0.7 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of plants.
  1. Experience: Five years' experience in landscape installation in addition to requirements in Section 014000 "Quality Requirements."
  2. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
  3. Pesticide Applicator: State licensed, commercial.
- B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
- C. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
  1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container-grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches (150 mm) above the root flare for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above the root flare for larger sizes.
  2. Other Plants: Measure with stems, petioles, and foliage in their normal position.
- D. Plant Material Observation: The Owner's Representative, Bill Moulton, will tag trees at the place of growth. The Landscape Architect may observe plant material at Project site before

planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Architect may also observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and may reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Owner's Representative (Bill Moulton, 859-572-5445 or moultonw1@nku.edu) of sources of planting materials for tagging in advance of delivery to site.
2. Selection and acceptance of trees at the nursery shall not affect the right of review and rejection during delivery and installation.

#### 0.8 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws if applicable.
- B. Bulk Materials:
  1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
  2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
  3. Accompany each delivery of bulk materials with appropriate certificates.
- C. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.
- D. Handle planting stock by root ball.
- E. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F (16 to 18 deg C) until planting.
- F. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
  1. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.
- G. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.
- H. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate

aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
2. Do not remove container-grown stock from containers before time of planting.
3. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.

## 0.9 FIELD CONDITIONS

- A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of plantings and construction contiguous with new plantings by field measurements before proceeding with planting work.
- B. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
  1. Spring Planting: March 15 and June 15.
  2. Fall Planting: September 15 and November 15.
- C. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.
- D. Tree Holding: Trees may be dug and held at nursery, or held at temporary holding location until ready for planting at the Project Site. Locations of temporary tree holding shall be approved by the Owner's Representative.
- E. Tree Maintenance: Maintain and protect trees from the time of tagging until they are transported to the Project Site. Maintenance to include spraying, fertilizing, watering, pruning, etc. Root balls must be covered with soil, wet peat, or other acceptable material. Protect balls and roots from freezing, drying winds, and/or mechanical damage. Water as necessary until planted.
- F. Fall Digging Hazards: Tree species noted as Fall Digging Hazards shall be dug in spring only. Digging at times other than spring shall be done at Contractor's risk, and shall not relieve him of the obligation of Guarantee.

## 0.10 WARRANTY

- A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
  1. Failures include, but are not limited to, the following:

- a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.
  - b. Structural failures including plantings falling or blowing over.
  - c. Faulty performance of tree grates.
  - d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
2. Warranty Periods: From date of planting completion.
  - a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
  - b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.
  - c. Trees noted on the Drawings as Fall Digging Hazard: 24 months.
3. Include the following remedial actions as a minimum:
  - a. Immediately remove dead plants and replace unless required to plant in the succeeding planting season.
  - b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
  - c. A limit of one replacement of each plant is required except for losses or replacements due to failure to comply with requirements.
  - d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

## **PART 2 - PRODUCTS**

### **0.1 PLANT MATERIAL**

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
  1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch (19 mm) in diameter; or with stem girdling roots are unacceptable.
  2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.
- C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

- D. Labeling: Label each plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant.
- E. If formal arrangements or consecutive order of plants is indicated on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

## 0.2 FERTILIZERS

- A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following compositions:
  - 1. Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- B. Slow-release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorous and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- C. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
  - 1. Size: 5-gram tablets.
  - 2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

## 0.3 MULCHES

- A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
  - 1. Type: Double-Shredded hardwood.
  - 2. Size Range: 3 inches (76 mm) maximum, 1/2 inch (13 mm) minimum.
  - 3. Color: Natural.

## 0.4 PESTICIDES

- A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.

- C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

## 0.5 TREE-STABILIZATION MATERIALS

### A. Trunk-Stabilization Materials:

1. Upright and Guy Stakes: Rough-sawn, sound, new hardwood, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal (38-by-38-mm actual) by length indicated, pointed at one end.
2. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or turnbuckles.
3. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch (2.7 mm) in diameter.
4. Guy Cables: Five-strand, 3/16-inch- (4.8-mm-) diameter, galvanized-steel cable, with zinc-coated turnbuckles, a minimum of 3 inches (75 mm) long, with two 3/8-inch (10-mm) galvanized eyebolts.
5. Flags: Standard surveyor's plastic flagging tape, white, 6 inches (150 mm) long.

## 0.6 MISCELLANEOUS PRODUCTS

- A. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.
- B. Burlap: Non-synthetic, biodegradable.
- C. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per lb (0.45 kg) of vesicular-arbuscular mycorrhizal fungi and 95 million spores per lb (0.45 kg) of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

## 0.7 TEMPORARY TREE-WATERING DEVICES

- A. Slow-Release Watering Device: Standard product manufactured for drip irrigation of plants and emptying its water contents over an extended time period.
  1. Color: green.

## **PART 3 - EXECUTION**

### 0.1 EXAMINATION

- A. Examine areas to receive plants, with Installer present, for compliance with requirements and conditions affecting installation and performance of the Work.
  1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel,

- paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
  - 2. Verify that plants and vehicles loaded with plants can travel to planting locations with adequate overhead clearance.
  - 3. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
  - 4. Uniformly moisten excessively dry soil that is not workable or which is dusty.
- B. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

## 0.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
- C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.
- D. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.

## 0.3 PLANTING AREA ESTABLISHMENT

- A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation."
- B. Placing Planting Soil: Place manufactured planting soil over exposed subgrade.
- C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- D. Application of Mycorrhizal Fungi: Broadcast dry product uniformly over prepared soil at application rate according to manufacturer's written recommendations.

## 0.4 EXCAVATION FOR TREES AND SHRUBS

- A. Planting Pits and Trenches:
  - 1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom

- raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
2. Excavate approximately three times as wide as ball diameter for balled and burlapped, and container-grown stock.
  3. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
  4. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
  5. Maintain angles of repose of adjacent materials to ensure stability. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
  6. Maintain supervision of excavations during working hours.
  7. Keep excavations covered or otherwise protected overnight.
  8. If drain tile is indicated on Drawings or required under planting areas, excavate to top of porous backfill over tile.
- B. Backfill Soil: Subsoil and topsoil removed from excavations may not be used as backfill soil unless otherwise indicated.
- C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
1. Hardpan Layer: Drill 6-inch- (150-mm-) diameter holes, 24 inches (600 mm) apart, into free-draining strata or to a depth of 10 feet (3 m), whichever is less, and backfill with free-draining material.
- D. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.
- E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

## 0.5 TREE, SHRUB, AND VINE PLANTING

- A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.
- B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.
- C. Balled and Burlapped Stock: Set each plant plumb and in center of planting pit or trench with root flare 2 inches (50 mm) above adjacent finish grades.
1. Backfill: Planting soil according to Section 329113 "Soil Preparation."
  2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove

- from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
  4. Continue backfilling process. Water again after placing and tamping final layer of soil.
- D. Container-Grown Stock: Set each plant plumb and in center of planting pit or trench with root flare 1 inch (25 mm) adjacent finish grades.
1. Backfill: Planting soil according to Section 329113 "Soil Preparation."
  2. Carefully remove root ball from container without damaging root ball or plant.
  3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
  4. Continue backfilling process. Water again after placing and tamping final layer of soil.
- E. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

#### 0.6 TREE, SHRUB, AND VINE PRUNING

- A. Remove only dead, dying, or broken branches. Do not prune for shape.
- B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.
- C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.
- D. Do not apply pruning paint to wounds.

#### 0.7 TREE STABILIZATION

- A. Trunk Stabilization by Upright Staking and Tying: Install trunk stabilization if site and plant material conditions warrant staking, as follows unless otherwise indicated:
  1. Upright Staking and Tying: Stake trees only as required to prevent wind tip out. Use a minimum of two stakes of length required to penetrate at least 18 inches (450 mm) below bottom of backfilled excavation and to extend at least 72 inches (1830 mm) above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.
  2. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
  3. Support trees with two strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.

0.8 GROUND COVER AND PLANT PLANTING

- A. Set out and space ground cover and plants other than trees, shrubs, and as indicated on Drawings in even rows with triangular spacing.
- B. Use planting soil for backfill.
- C. Dig holes large enough to allow spreading of roots.
- D. For rooted cutting plants supplied in flats, plant each in a manner that minimally disturbs the root system but to a depth not less than two nodes.
- E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
- F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
- G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

0.9 PLANTING AREA MULCHING

- A. Mulch backfilled surfaces of planting areas and other areas indicated.
  - 1. Trees in Turf Areas: Apply organic mulch ring of 3-inch (75-mm) average thickness, with [24-inch (600-mm) radius around trunks or stems. Do not place mulch within 3 inches (75 mm) of trunks or stems.
  - 2. Organic Mulch in Planting Areas: Apply 2-inch (50-mm) average thickness of organic mulch over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches (75 mm) of trunks or stems.

0.10 EDGING INSTALLATION

- A. Shovel-Cut Edging: Separate mulched areas from turf areas with a 45-degree, 4- to 6-inch- (100- to 150-mm-) deep, shovel-cut edge as indicated on Drawings.

0.11 INSTALLING SLOW-RELEASE WATERING DEVICE

- A. Provide one device for each tree.
- B. Place device on top of the mulch at base of tree stem and fill with water according to manufacturer's written instructions.

0.2 PLANT MAINTENANCE

- A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades

or vertical position, and performing other operations as required to establish healthy, viable plantings.

- B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.
- C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

### 0.3 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents according to authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.
- B. Pre-Emergent Herbicides (Selective and Nonselective): Apply to tree, shrub, and ground-cover areas according to manufacturer's written recommendations. Do not apply to seeded areas.
- C. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

### 0.4 REPAIR AND REPLACEMENT

- A. General: Repair or replace existing or new trees and other plants that are damaged by construction operations, in a manner approved by Architect.
  - 1. Submit details of proposed pruning and repairs.
  - 2. Perform repairs of damaged trunks, branches, and roots within 24 hours, if approved.
  - 3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.
- B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
  - 1. Provide new trees of same size as those being replaced for each tree.
  - 2. Species of Replacement Trees: Same species being replaced.

### 0.5 CLEANING AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

- B. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.
- C. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.
- D. After installation and before Substantial Completion remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.
- E. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

#### 0.6 MAINTENANCE SERVICE

- A. Maintenance Service for Trees and Shrubs: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:
  - 1. Maintenance Period: Three months from date of planting completion.
- B. Maintenance Service for Ground Cover and Other Plants: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:
  - 1. Maintenance Period: Three months from date of planting completion.

#### **END OF SECTION 329300**

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## **SECTION 331100 - WATER DISTRIBUTION**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This section includes water-distribution piping and related components outside of the building for domestic, fire, and combined water service mains.

#### **1.3 DEFINITIONS**

- A. PE: Polyethylene plastic.
- B. PP: Polypropylene plastic.
- C. PVC: Polyvinyl chloride plastic.
- D. NKWD: Northern Kentucky Water District
- E. KYTC: Kentucky Transportation Cabinet

#### **1.4 SUBMITTALS**

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
- C. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.
- D. Operation and Maintenance Data: For water valves and specialties to include in emergency, operation, and maintenance manuals.

#### **1.5 QUALITY ASSURANCE**

- A. All work must be done in compliance with the local water jurisdiction having authority, the local building department, the governing fire department, and all applicable state and national codes. If local codes conflict with project specifications or project plans the contractor should contact the Construction Manager.

- B. Minimum working pressures: The following are minimum pressure requirements for piping and specialties:
  - 1. Domestic Water Service: 200 psi
  - 2. Fire Protection Water Service: 250 psi
- C. Regulatory Requirements:
  - 1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
  - 2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
  - 3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
- D. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.
- G. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.
- H. NSF Compliance:
  - 1. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

#### 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:
  - 1. Ensure that valves are dry and internally protected against rust and corrosion.
  - 2. Protect valves against damage to threaded ends and flange faces.
  - 3. Set valves in best position for handling. Set valves closed to prevent rattling.
- B. During Storage: Use precautions for valves, including fire hydrants, according to the following:
  - 1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
  - 2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.
- C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.
- D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
- E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

- F. Protect flanges, fittings, and specialties from moisture and dirt.

## 1.7 PROJECT CONDITIONS

- A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:
  - 1. Notify Construction Manager no fewer than two days in advance of proposed interruption of service.
  - 2. Do not proceed with interruption of water-distribution service without Construction Manager's permission.

## 1.8 COORDINATION

- A. Coordinate connection to water main with utility company.
- B. Coordinate water main installation with other utility work.

## PART 2 - PRODUCTS

### 2.1 DUCTILE-IRON PIPE AND FITTINGS

- A. Mechanical-Joint, Ductile-Iron Pipe: Class 52 minimum, 250 psi minimum pressure rating, AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated. The interior of the pipe shall be cement-mortar lined and seal coated in accordance with AWWA C104. The exterior of all pipe shall receive wither coal tar or asphalt base coating a minimum of 1 mil thick.
  - 1. Mechanical-Joint, Ductile-Iron Fittings: 250 psi minimum pressure rating, AWWA C110, ductile-iron standard pattern or AWWA C153, ductile-iron compact pattern.
  - 2. Glands, Gaskets, and Bolts: AWWA C111, ductile-iron glands, rubber gaskets, and Core 10 Alloy Steel only bolts.
- B. Push-on-Joint, Ductile-Iron Pipe: Class 52 minimum, 250 psi minimum pressure rating, AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated. The interior of the pipe shall be cement-mortar lined and seal coated in accordance with AWWA C104. The exterior of all pipe shall receive wither coal tar or asphalt base coating a minimum of 1 mil thick.
  - 1. Push-on-Joint, Ductile-Iron Fittings: 250 psi minimum pressure rating, AWWA C110, ductile-iron standard pattern or AWWA C153, ductile-iron compact pattern.
  - 2. Gaskets: AWWA C111, rubber.

### 2.2 GATE VALVES

- A. AWWA, Gate Valves:
  - 1. Nonrising-Stem, High-Pressure, Resilient-Seated Gate Valves:

- a. Description: Ductile-iron body and bonnet; with bronze or ductile-iron gate, resilient seats, bronze stem, and stem nut.
  - 1) Standard: AWWA C509.
  - 2) Minimum Pressure Rating: 250 psig.
  - 3) End Connections: Push on or mechanical joint.
  - 4) Interior Coating: Complying with AWWA C550.

## 2.3 GATE VALVE ACCESSORIES AND SPECIALTIES

### A. Tapping-Sleeve Assemblies:

- 1. Description: Sleeve and valve compatible with drilling machine.
  - a. Standard: MSS SP-60.
  - b. Tapping Sleeve: Cast- or ductile-iron or stainless-steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.
  - c. Valve: AWWA, cast-iron, nonrising-stem, resilient-seated gate valve with one raised face flange mating tapping-sleeve flange.

### B. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel approximately 5 inches in diameter.

- 1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

### C. Indicator Posts: UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.

## 2.4 CHECK VALVES

### A. AWWA Check Valves:

- 1. Description: Swing-check type with resilient seat. Include interior coating according to AWWA C550 and ends to match piping.
  - a. Standard: AWWA C508.
  - b. Pressure Rating: 250 psig.

## 2.5 DETECTOR CHECK VALVES

### A. Detector Check Valves:

- 1. Description: Galvanized cast-iron body, bolted cover with air-bleed device for access to internal parts, and flanged ends. Include one-piece bronze disc with bronze bushings, pivot, and replaceable seat. Include threaded bypass taps in inlet and outlet for bypass meter connection. Set valve to allow minimal water flow through bypass meter when major water flow is required.

- a. Standards: UL 312 and FMG approved.
  - b. Pressure Rating: 250 psig.
  - c. Bypass Water Meter: AWWA C700, disc type, at least one-fourth size of detector check valve. Include meter, bypass piping, gate valves, check valve, and connections to detector check valve.
2. Description: Iron body, corrosion-resistant clapper ring and seat ring material, flanged ends, with connections for bypass and installation of water meter.
  - a. Standards: UL 312 and FMG approved.
  - b. Pressure Rating: 250 psig.

## 2.6 WATER METERS

- A. Water meters are to be per the requirements of the authority having jurisdiction.

## 2.7 BACKFLOW PREVENTERS

- A. Double-Check, Backflow-Prevention Assemblies:
  1. As required per the jurisdiction having authority.
- B. Double-Check, Detector-Assembly Backflow Preventers:
  1. As required per the jurisdiction having authority.

## 2.8 WATER METER BOXES

- A. As required per the jurisdiction having authority.
- B. Description: Cast-iron body and cover for disc-type water meter, with lettering "WATER METER" in cover; and with slotted, open-bottom base section of length to fit over service piping.

## 2.9 CONCRETE VAULTS

- A. As required per the jurisdiction having authority.
- B. Description: Precast, reinforced-concrete vault.
  1. Drain: Provide a gravity drain line from the pit to a suitable open daylight drainage point or storm sewer; or provide a sump pump and appurtenances with associated piping to suitable outlet point.

## 2.10 FIRE HYDRANTS

- A. Dry-Barrel Fire Hydrants:
  1. As required per the jurisdiction having authority.

2. Description: Freestanding, with one NPS 4-1/2 and two NPS 2-1/2 outlets, 5-1/4-inch main valve, drain valve, and NPS 6 mechanical-joint inlet. Include interior coating according to AWWA C550. Hydrant barrel shall have safety breakage feature above the ground line. Hydrant shall have cast-iron body, compression-type valve opening against pressure and closing with pressure so that the valve remains closed should the barrel be broken off.
  - a. Standard: AWWA C502.
  - b. Pressure Rating: Minimum 250 psig.
  - c. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
  - d. Operating and Cap Nuts: Pentagon, 1-1/2 inches point to flat.
  - e. Direction of Opening: Open hydrant valve by turning operating nut to left or counterclockwise.

## 2.11 FIRE DEPARTMENT CONNECTIONS

### A. Fire Department Connections:

1. As required per the jurisdiction having authority.

## PART 3 - EXECUTION

### 3.1 EARTHWORK

#### A. General:

1. Conduit Under Pavement: Refer to Northern Kentucky Water District Standard Specifications Part 3.20.
2. Conduit Not Under Pavement: Refer to Northern Kentucky Water District Standard Specifications Part 3.19.
3. Conduit Over/Under Pipe Barrel: Refer to Northern Kentucky Water District Standard Specifications Part 3.18.

#### B. Excavation For Utility Trenches:

1. Excavate trenches to indicated slopes, lines, depths, and invert elevations.
2. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit.
3. Excavate trench walls per Northern Kentucky Water District Standard Specifications Part 3.05 and geotechnical report as identified on the Drawings.
4. Where encountering rock or another unyielding bearing surface, carry trench excavation 6 inches below invert elevation to receive bedding course.

#### C. Utility Trench Backfill:

1. Place and compact bedding course as required by KYTC Standard Specifications Item 701.03.03, NKWD Standard Specifications Part III, and geotechnical report. Type 2 bedding consists of structural backfill extending at least 3 inches (75 mm) for all KYTC Item 810 rigid pipe conduits and 6 inches (150 mm) for all other conduits below the bottom of the conduit for the full width of the trench. Extend the bedding up around the pipe for a depth of not less than 30 percent of the rise of the conduit. Shape the bedding to fit the conduit with recesses shaped to receive the bell of bell-and-spigot pipe. Leave the bedding below the middle one-third of the pipe span uncompacted. Compact the remaining bedding according to KYTC Standard Specifications Item 701.03.03.

2. Use Type 2 bedding for Types A, B, C, and D conduits except for long span structures and for conduits that require Type 3 bedding.
3. Type 3 bedding consists of a natural foundation with recesses shaped to receive the bell of bell-and-spigot pipe. Scarify and loosen the middle one-third of the pipe span.
4. Use Type 3 bedding for Type C and Type D conduits of the following materials: KYTC Items 810.03.
5. Structural backfill for KYTC Item 701 bedding and backfill shall consist of limestone, gravel, natural sand, sand manufactured from stone, or foundry sand. Provide Type I or Type II structural backfill per the requirements of KYTC Item 701.02.
6. Non-structural backfill should consist of clean, inorganic soil free of any miscellaneous materials, cobbles, and boulders. The fill should be placed in uniform, thin lifts and carefully compacted to a unit dry weight equal to 100 percent in structure areas and at least 98 percent of the maximum dry weight below pavement areas. The moisture content of the fill should be maintained at -2 to +1 percent of the optimum moisture content as determined in the laboratory by the Standard Test Methods for Moisture-Density Relations of Soils (ASTM D 698). Fill should not be placed in a frozen condition or upon a frozen subgrade.
7. Place backfill to the limits described and according to the compaction requirements of NKWD Part III. Place the backfill in the trench and embankment outside the trench uniformly on both sides of the conduit for all conduit installations.
  - a. Type A and B. Backfill Types A and B conduits except for long span structures as follows
    - 1) In a cut situation, place and compact structural backfill above the bedding for the full depth of the trench. Within the trench and more than 4 feet (1.2 m) above the top of the conduit, if the trench can accommodate compaction equipment, the Contractor may construct Item 203 Embankment. For plastic pipe with an ID 8 inch (200 mm) or less, place and compact structural backfill above the bedding for the full depth of the trench.
    - 2) In a fill situation, place and compact structural backfill above the bedding for the full depth of the trench specified in 603.05.B. Above these limits, uniformly place the lesser of one pipe span or 4 feet (1.2 m) of structural backfill on each side of the conduit and to a depth of 2 feet (0.6 m) above the top of the conduit. Construct the embankment outside the limits of the backfill. For plastic pipe with an ID 8 inch (200 mm) or less, place and compact structural backfill above the bedding for the full depth of the trench.
  - b. Type C and D. Backfill Type C and D conduits as follows:
    - 1) In a cut situation, for plastic pipe, place and compact structural backfill above the bedding and to 12 inches (300 mm) over the top of the pipe. All other conduit material types place and compact backfill. For plastic pipe with an ID 8 inch (200 mm) or less, place and compact structural backfill above the bedding for the full depth of the trench.
    - 2) In a fill situation, for plastic pipe, place and compact structural backfill above the bedding for the full depth of the trench specified in 603.05.B. Above these limits, uniformly place the lesser of one pipe span or 4 feet (1.2 m) of structural backfill on each side of the conduit and vertically to the top of the conduit. Then place for a depth of 12 inches (300 mm) structural backfill over the top of the pipe equal to the trench width centered on the pipe center line. Construct the embankment outside the limits of the backfill. All other conduit material types place and compact backfill. For plastic pipe with an ID 8 inch (200 mm) or less, place and compact structural backfill above the bedding for the full depth of the trench.
8. Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
9. All fill soils shall be placed in accordance with the article "Compaction of Soil Backfills and Fills" from the Earth Moving Specification Section 312000.

10. Coordinate backfilling with utilities testing.
11. Fill voids with approved backfill materials as shoring and bracing, and sheeting is removed.
12. Place and compact final backfill of satisfactory soil material to final subgrade.
13. Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
14. All fill soils shall be placed in accordance with the article "Compaction of Soil Backfills and Fills" from the Earth Moving Specification Section 312000.
15. Coordinate backfilling with utilities testing.
16. Fill voids with approved backfill materials as shoring and bracing, and sheeting is removed.
17. Place and compact final backfill of satisfactory soil material to final subgrade.

### 3.2 PIPING INSTALLATION

- A. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.
  1. Make connections larger than NPS 2 with tapping machine in accordance with the jurisdiction having authority.
  2. Make connections NPS 2 and smaller with drilling machine in accordance with the jurisdiction having authority.
- B. Comply with NFPA 24 for fire-service-main piping installation.
- C. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.
- D. Bury piping with depth of cover over top at least 48 inches below finish grade.
- E. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.
- F. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.
  1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.
- G. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

### 3.3 ANCHORAGE INSTALLATION

- A. Anchorage, General: Only the following may be used for anchorages and restrained-joint types:
  1. Concrete thrust blocks.
  2. Locking mechanical joints.
  3. Set-screw mechanical retainer glands.
  4. Bolted flanged joints.
  5. Pipe clamps and tie rods.
- B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches.

- C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

### 3.4 VALVE INSTALLATION

- A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.
- B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.
- C. MSS Valves: Install as component of connected piping system.
- D. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.

### 3.5 DETECTOR-CHECK VALVE INSTALLATION

- A. Install in vault or aboveground.
- B. Install for proper direction of flow. Install bypass with water meter, gate valves on each side of meter, and check valve downstream from meter.
- C. Support detector check valves, meters, shutoff valves, and piping on brick or concrete piers.

### 3.6 WATER METER INSTALLATION

- A. Install water meters, piping, and specialties according to utility company's written instructions.

### 3.7 BACKFLOW PREVENTER INSTALLATION

- A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.
- B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.
- C. Do not install bypass piping around backflow preventers.
- D. Support NPS 2-1/2 and larger backflow preventers, valves, and piping near floor and on brick or concrete piers.

### 3.8 WATER METER BOX INSTALLATION

- A. Install water meter boxes in paved areas flush with surface.
- B. Install water meter boxes in grass or earth areas with top 1 inch above surface.

### 3.9 CONCRETE VAULT INSTALLATION

- A. Install precast concrete vaults according to ASTM C 891.

### 3.10 FIRE HYDRANT INSTALLATION

- A. General: Install each fire hydrant with separate gate valve in supply pipe, anchor with restrained joints and thrust blocks, and support in upright position.
- B. AWWA Fire Hydrants: Comply with AWWA M17.

### 3.11 FIRE DEPARTMENT CONNECTION INSTALLATION

- A. Install ball drip valves at each check valve for fire department connection to mains.

### 3.12 CONNECTIONS

- A. Connect water-distribution piping to existing water main. Use tapping sleeve and tapping valve, or service clamp and corporation valve.
- B. Connect water-distribution piping to interior domestic water and fire-suppression piping if in place. Coordinate connection with plumber.
- C. Connect drainage piping from concrete vault drains to storm-drainage system swale or pipe.

### 3.13 FIELD QUALITY CONTROL

- A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
- B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.
  - 1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.
  - 2. All pipe, fittings and other materials found to be defective under test shall be removed and replaced at the contractors expense.
- C. Prepare reports of testing activities.

### 3.14 CLEANING

- A. Clean and disinfect water-distribution piping as follows:
  - 1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.

2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
  - a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
  - b. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
  - c. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.
- B. Prepare reports of purging and disinfecting activities.

**END OF SECTION 331100**

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**SECTION 333100 – SANITARY SEWERS****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

**1.2 SUMMARY**

- A. This Section includes gravity-flow, non-pressure sanitary sewerage outside the building, with the following components:
  - 1. Cleanouts.
  - 2. Precast concrete manholes.

**1.3 DEFINITIONS**

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. PP: Polypropylene plastic.
- C. PVC: Polyvinyl chloride plastic.
- D. KYTC: Kentucky Transportation Cabinet
- E. SD-1: Sanitation District No. 1

**1.4 PERFORMANCE REQUIREMENTS**

- A. Gravity-Flow, Non-pressure, Piping Pressure Rating: at least equal to system test pressure.

**1.5 SUBMITTALS**

- A. Product Data: For the following:
  - 1. Pipe.
  - 2. Cleanouts.
- B. Shop Drawings: For the following:
  - 1. Manholes: Include plans, sections, details, and frames and covers.
- C. Coordination Drawings: Show pipe sizes, and locations. Show other piping in same trench and clearances from sewerage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

- D. Profile Drawings (as necessary): Show system piping in elevation view. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet and vertical scale of not less than 1 inch equals 5 feet. Indicate manholes and piping. Show types, sizes, materials, and locations of other utilities crossing system piping.

## 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic manholes, pipe, and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.
- C. Handle manholes according to manufacturer's written rigging instructions.

## 1.7 PROJECT CONDITIONS

- A. Interruption of Existing Sanitary Sewerage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
  - 1. Notify Construction Manager no fewer than two days in advance of proposed interruption of service.
  - 2. Do not proceed with interruption of service without Construction Manager 's permission.

## PART 2 - PRODUCTS

### 2.1 PVC PIPE AND FITTINGS

- A. PVC Sewer Pipe and Fittings, NPS 15 and Smaller: ASTM D 3034, SDR 35, with integral bell-and-spigot rubber gasketed joints per ASTM D 3212.
- B. PVC Sewer Pipe and Fittings, NPS 18 and Larger: ASTM F 679, T-1 wall thickness, with integral bell-and-spigot rubber gasketed joints per ASTM D 3212.

### 2.2 CLEANOUTS

- A. PVC with cast iron adaptor: Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping. Include cast iron adaptor and threaded brass closure plug.

### 2.3 MANHOLES

- A. Standard Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
  - 1. Diameter: 48 inches minimum, unless otherwise indicated.
  - 2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
  - 3. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.

4. Riser Sections: 4-inch minimum thickness, and of length to provide depth indicated.
5. Top Section: Eccentric-cone type, unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
6. Joint Sealant: Precast manhole section joints shall be formed entirely of concrete employing a round, wedge shaped profile gasket, and when assembled shall be self centering and make a uniform watertight joint conforming to ASTM C 443. The joint shall also be sealed with a bituminous mastic joint sealing compound.
7. Resilient Pipe Connectors: Sewer pipe to manhole connections on all sanitary sewers shall be flexible and watertight. Sewer pipe shall be sealed in the manhole section pipe openings with a resilient connector meeting the requirements of ASTM C 923. The connection may be any of the following types:

- a. Rubber sleeve with stainless steel banding
- b. Rubber gasket compression

Resilient connector shall be cast integrally into the wall of the manhole section at the time of manufacture, or, shall be installed by mechanical means in openings cut into manhole wall per ASTM C 923.

8. Steps: ASTM A 615/A 615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP; Ductile Iron; or Cast Aluminum. Steps shall be wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Steps shall be equally spaced. Whenever possible steps shall not be placed directly above manhole flow channel. Omit steps if total depth from floor of manhole to finished grade is less than 48 inches.
9. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover.
10. Protective Coating: Plant-applied, SSPC-Paint 16, coal-tar, epoxy-polyamide paint; 10-mil minimum thickness applied to interior surfaces.
11. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch-minimum width flange and 26-inch- diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "SANITARY SEWER." Manhole Frames and Covers shall be heavy duty.

- a. Material: ASTM A 536, Grade 60-40-18 ductile iron, unless otherwise indicated.

## 2.4 CONCRETE

- A. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.

1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.

- a. Invert Slope: minimum fall of 0.10 foot across manhole.

2. Benches: Concrete, sloped to drain into channel.

- B. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water/cementitious materials ratio.

1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

## 2.5 MISCELLANEOUS MATERIALS

- A. Paint: SSPC-Paint 16.

## PART 3 - EXECUTION

### 3.1 EARTHWORK

- A. General:
  1. Conduit Under Pavement: Refer to KYTC Standard Specifications Item 701.02.
  2. Conduit Not Under Pavement: Refer to KYTC Standard Specifications Item 701.02.
- B. Excavation For Utility Trenches:
  1. Excavate trenches to indicated slopes, lines, depths, and invert elevations.
  2. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit.
  3. Excavate trench walls per KYTC Standard Specifications Item 701.03 and geotechnical report as identified on the Drawings.
  4. Where encountering rock or another unyielding bearing surface, carry trench excavation 6 inches below invert elevation to receive bedding course.
- C. Utility Trench Backfill:
  1. Place and compact bedding course as required by KYTC Standard Specifications Item 701.03.03 and geotechnical report. Type 2 bedding consists of structural backfill extending at least 3 inches (75 mm) for all KYTC Item 810 rigid pipe conduits and 6 inches (150 mm) for all other conduits below the bottom of the conduit for the full width of the trench. Extend the bedding up around the pipe for a depth of not less than 30 percent of the rise of the conduit. Shape the bedding to fit the conduit with recesses shaped to receive the bell of bell-and-spigot pipe. Leave the bedding below the middle one-third of the pipe span uncompacted. Compact the remaining bedding according to KYTC Standard Specifications Item 701.03.03.
  2. Use Type 2 bedding for Types A, B, C, and D conduits except for long span structures and for conduits that require Type 3 bedding.
  3. Type 3 bedding consists of a natural foundation with recesses shaped to receive the bell of bell-and-spigot pipe. Scarify and loosen the middle one-third of the pipe span.
  4. Use Type 3 bedding for Type C and Type D conduits of the following materials: KYTC Items 810.03.
  5. Structural backfill for KYTC Item 701 bedding and backfill shall consist of limestone, gravel, natural sand, sand manufactured from stone, or foundry sand. Provide Type I or Type II structural backfill per the requirements of KYTC Item 701.02.
  6. Non-structural backfill should consist of clean, inorganic soil free of any miscellaneous materials, cobbles, and boulders. The fill should be placed in uniform, thin lifts and carefully compacted to a unit dry weight equal to 100 percent in structure areas and at least 98 percent of the maximum dry weight below pavement areas. The moisture content of the fill should be maintained at -2 to +1 percent of the optimum moisture content as determined in the laboratory by the Standard Test Methods for Moisture-Density Relations of Soils (ASTM D 698). Fill should not be placed in a frozen condition or upon a frozen subgrade.

7. Place backfill to the limits described and according to the compaction requirements of KYTC Item 701.02. Place the backfill in the trench and embankment outside the trench uniformly on both sides of the conduit for all conduit installations.
  - a. Type A and B. Backfill Types A and B conduits except for long span structures as follows
    - 1) In a cut situation, place and compact structural backfill above the bedding for the full depth of the trench. Within the trench and more than 4 feet (1.2 m) above the top of the conduit, if the trench can accommodate compaction equipment, the Contractor may construct Item 203 Embankment. For plastic pipe with an ID 8 inch (200 mm) or less, place and compact structural backfill above the bedding for the full depth of the trench.
    - 2) In a fill situation, place and compact structural backfill above the bedding for the full depth of the trench specified in 603.05.B. Above these limits, uniformly place the lesser of one pipe span or 4 feet (1.2 m) of structural backfill on each side of the conduit and to a depth of 2 feet (0.6 m) above the top of the conduit. Construct the embankment outside the limits of the backfill. For plastic pipe with an ID 8 inch (200 mm) or less, place and compact structural backfill above the bedding for the full depth of the trench.
  - b. Type C and D. Backfill Type C and D conduits as follows:
    - 1) In a cut situation, for plastic pipe, place and compact structural backfill above the bedding and to 12 inches (300 mm) over the top of the pipe. All other conduit material types place and compact backfill. For plastic pipe with an ID 8 inch (200 mm) or less, place and compact structural backfill above the bedding for the full depth of the trench.
    - 2) In a fill situation, for plastic pipe, place and compact structural backfill above the bedding for the full depth of the trench specified in 603.05.B. Above these limits, uniformly place the lesser of one pipe span or 4 feet (1.2 m) of structural backfill on each side of the conduit and vertically to the top of the conduit. Then place for a depth of 12 inches (300 mm) structural backfill over the top of the pipe equal to the trench width centered on the pipe center line. Construct the embankment outside the limits of the backfill. All other conduit material types place and compact backfill. For plastic pipe with an ID 8 inch (200 mm) or less, place and compact structural backfill above the bedding for the full depth of the trench.
8. Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
9. All fill soils shall be placed in accordance with the article "Compaction of Soil Backfills and Fills" from the Earth Moving Specification Section 312000.
10. Coordinate backfilling with utilities testing.
11. Fill voids with approved backfill materials as shoring and bracing, and sheeting is removed.
12. Place and compact final backfill of satisfactory soil material to final subgrade.

### 3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewerage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, contact Construction Manager.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.

- C. Install manholes for changes in direction, unless fittings are indicated. Use fittings for branch connections, unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. Install gravity-flow, non-pressure, drainage piping according to the following:
  - 1. Install piping pitched down in direction of flow, at minimum slope of 2 percent, unless otherwise indicated.
  - 2. Install piping with 36-inch minimum cover unless otherwise indicated.
  - 3. Install PVC sewer piping according to ASTM D 2321 except as modified by this section or as required by SD1.
- F. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

### 3.3 PIPE JOINT CONSTRUCTION

- A. Preparatory to making pipe joints, all joint surfaces shall be cleaned of all dirt, dust, and foreign matter and shall be dry, smooth, and free of imperfections before placing joining materials. Gaskets, lubricants, primers, adhesives, or other joining materials shall be used as recommended by the pipe or joint manufacturer's specifications. Generally, lubricants and primers and adhesives shall be placed on both the bell and spigot portions of the joint. The pipe shall then be placed, fitted, joined, and adjusted in such a workmanlike manner as to obtain the degree of water-tightness required. In the event that pipe previously laid is disturbed due to any cause, it shall be removed and re-laid.
- B. Joints that show leakage will not be accepted. If after backfilling and inspection, any joints are found to be allowing groundwater to enter the sewer, such joints shall be sealed by the contractor at no cost to the owner.
- C. No fittings (except service wyes and repair couplings) shall be allowed in gravity sewers. Open ends of wyes shall be plugged or sealed until service laterals are installed.
- D. Join gravity-flow, non-pressure, drainage piping according to the following:
  - 1. Join ABS sewer piping according to ASTM D 2321 except as modified by this section or as required by SD1.
  - 2. Join PVC sewer piping according to ASTM D 2321 except as modified by this section or as required by SD1.
  - 3. Join dissimilar pipe materials with non-pressure-type, flexible couplings.

### 3.4 MANHOLE INSTALLATION

- A. General: Install manholes complete with appurtenances and accessories indicated.
- B. Form continuous concrete channels and benches between inlets and outlet.
- C. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere, unless otherwise indicated.

### 3.5 CONCRETE PLACEMENT

- A. Place cast-in-place concrete according to ACI 318/318R.

### 3.6 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
  - 1. Use medium-duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
  - 2. Use heavy-duty, top-loading classification cleanouts in paved foot-traffic, vehicle-traffic, roads, and service areas.
- B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding grade.
- C. Set cleanout frames and covers in asphalt or concrete pavement with tops flush with pavement surface.

### 3.7 CONNECTIONS

- A. Connect non-pressure, gravity-flow drainage piping to building's sanitary building drains specified in Division 22 Section "Sanitary Waste and Vent Piping."
- B. Make connections to existing piping and underground manholes.
  - 1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
  - 2. Make branch connections from side into existing piping, NPS 4 to NPS 20. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
  - 3. Make branch connections from side into existing piping, NPS 21 or larger, or to underground manholes by cutting opening into existing unit large enough to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall, unless otherwise indicated. On outside of pipe or manhole wall, encase entering connection in 6 inches of concrete for minimum length of 12 inches to provide additional support of collar from connection to undisturbed ground.
    - a. Use concrete that will attain minimum 28-day compressive strength of 3000 psi, unless otherwise indicated.
    - b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
  - 4. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

### 3.8 PAINTING

- A. Clean and prepare concrete manhole surfaces for field painting. Remove loose efflorescence, chalk, dust, grease, oils, and release agents. Roughen surface as required to remove glaze. Paint the following concrete surfaces as recommended by paint manufacturer:

1. Precast Concrete Manholes: All interior.

### 3.9 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.

1. Submit separate report for each system inspection.
2. Defects requiring correction include the following:
  - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
  - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
  - c. Crushed, broken, cracked, or otherwise damaged piping.
  - d. Infiltration: Water leakage into piping.
  - e. Exfiltration: Water leakage from or around piping.
3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of SD1.
3. Schedule tests and inspections by SD1 with at least 24 hours' advance notice. If SD1 does not have published procedures, or if sewer does not fall under SD1, perform tests as follows:
4. Hydrostatic Tests: Test sanitary sewerage according to requirements of SD1 and the following:
  - a. Allowable leakage is maximum of 50 gal./inch of nominal pipe size per mile of pipe, during 24-hour period.
  - b. Close openings in system and fill with water.
  - c. Purge air and refill with water.
  - d. Disconnect water supply.
  - e. Test and inspect joints for leaks.
5. Air Tests: Test sanitary sewerage according to requirements of SD1, UNI-B-6, and the following:
  - a. Option: Test plastic gravity sewer piping according to ASTM F 1417.

- C. Manholes: Perform hydraulic test according to ASTM C 969.

- D. Leaks and loss in test pressure constitute defects that must be repaired.

- E. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.10 CLEANING

- A. Clean interior of piping of dirt and superfluous material.

**END OF SECTION 333100**

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## **SECTION 334100 - STORM DRAINAGE**

### **PART 1 - GENERAL**

#### **1.1 RELATED DOCUMENTS**

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

#### **1.2 SUMMARY**

- A. This Section includes gravity-flow, non-pressure storm drainage outside the building, with the following components:
  - 1. Cleanouts.
  - 2. Drains, Catch Basins, Inlets, & Headwalls.
  - 3. Precast concrete & Cast-in-place concrete manholes.

#### **1.3 DEFINITIONS**

- A. PE: Polyethylene plastic.
- B. PVC: Polyvinyl chloride plastic.
- C. KYTC: Kentucky Transportation Cabinet

#### **1.4 PERFORMANCE REQUIREMENTS**

- A. Gravity-Flow, Non-pressure, Drainage-Piping Pressure Rating: 10-foot head of water. Pipe joints shall be at least silt tight, unless otherwise indicated.

#### **1.5 SUBMITTALS**

- A. Product Data: For the following:
  - 1. Pipe.
  - 2. Cleanouts.
  - 3. Trench Drains.
- B. Shop Drawings: For the following:
  - 1. Manholes: Include plans, sections, details, and frames and covers.
  - 2. Catch Basins, Headwalls and Stormwater Inlets. Include plans, sections, details, and frames, covers, and grates.
  - 3. Stormwater Detention Structures: Include plans, sections, details, frames, grates, and covers.

- C. Coordination Drawings: Show pipe sizes, and locations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
- D. Profile Drawings (as necessary): Show system piping in elevation view. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet and vertical scale of not less than 1 inch equals 5 feet. Indicate manholes and piping. Show types, sizes, materials, and locations of other utilities crossing system piping.

#### 1.6 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic manholes, pipe, and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.
- C. Handle manholes according to manufacturer's written rigging instructions.
- D. Handle catch basins, headwalls, and stormwater inlets according to manufacturer's written rigging instructions.

#### 1.7 PROJECT CONDITIONS

- A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
  - 1. Notify Construction Manager no fewer than two days in advance of proposed interruption of service.
  - 2. Do not proceed with interruption of service without Construction Manager 's permission.

### PART 2 - PRODUCTS

#### 2.1 GENERAL:

- A. Public Roadway Culverts: Refer to The Kentucky Transportation Cabinet Item 701.02.
- B. Conduit Under Pavement: Refer to The Kentucky Transportation Cabinet Item 701.02.
- C. Conduit Not Under Pavement: Refer to The Kentucky Transportation Cabinet Item 701.02.
- D. Private Drive Pipes and Bikeways: Refer to The Kentucky Transportation Cabinet Item 701.02.

#### 2.2 ALUMINIZED CORRUGATED METAL PIPE AND FITTINGS

- A. Per the latest version of the KYTC Standard Specifications and as noted on the Drawings.

#### 2.3 PE PIPE AND FITTINGS

- A. Per the latest version of the KYTC Standard Specifications and as noted on the Drawings.

## 2.4 PVC PIPE AND FITTINGS

- A. Per the latest version of the KYTC Standard Specifications and as noted on the Drawings.
- B. PVC Sewer Pipe and Fittings, NPS 15 and Smaller: ASTM D 3034, SDR 35, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.
- C. PVC Profile Gravity Sewer Pipe and Fittings: ASTM F 794 pipe, with bell-and-spigot ends; ASTM D 3034 fittings, with bell ends; and ASTM F 477, elastomeric seals.

## 2.5 REINFORCED CONCRETE PIPE AND FITTINGS

- A. Per the latest version of the KYTC Standard Specifications and as noted on the Drawings.

## 2.6 DUCTILE IRON PIPE

- A. Per KYTC 810.05 conforming to ANSI/AWWA C151/A21.51, service and extra-heavy classes, for gasketed joints.
- B. Gaskets: ANSI/AWWA C111/A21.11, rubber, compression type, thickness to match class of pipe.

## 2.7 CLEANOUTS

- A. PVC with cast iron adaptor: Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping. Include cast iron adaptor and threaded brass closure plug.

## 2.8 DRAINS

- A. Yard Drains: As noted on the Drawings.
- B. Trench Drains: As noted on the Drawings.

## 2.9 MANHOLES

- A. Per the latest version of the KYTC Standard Specifications and the latest version of the KYTC Standard Drawings.
  - 1. Diameter: 48 inches minimum, unless otherwise indicated on the drawings.
  - 2. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
  - 3. Riser Sections: 4-inch minimum thickness, and of length to provide depth indicated.
  - 4. Top Section: Eccentric-cone type, unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings. Steps: ASTM A 615/A 615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP; Ductile Iron; or Cast Aluminum. Steps shall be wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Steps shall be equally spaced. Whenever possible steps

shall not be placed directly above manhole flow channel. Omit steps if total depth from floor of manhole to finished grade is less than 48 inches.

5. Manhole Frames and Covers: Include lettering cast into cover, using wording equivalent to "STORM SEWER."
  - a. Frames and Covers must be heavy duty

## 2.10 CONCRETE

- A. General: Cast-in-place concrete according to the latest version of the KYTC Standard Specifications and the latest version of the KYTC Standard Drawings

## 2.11 CATCH BASINS

- A. Per the latest version of the KYTC Standard Specifications and the latest version of the KYTC Standard Drawings.
  1. See drawings for schedule of specific types of catch basins
  2. Frames and Grates:
    - a. Are to be heavy duty.
    - b. Are to be ADA compliant.
    - c. Are to be Bicycle safe.

## 2.12 STORMWATER DETENTION STRUCTURES

- A. As indicated on the Drawings and Per the jurisdiction having authority.

## 2.13 PIPE INLETS AND OUTLETS

- A. Headwalls: Per the latest version of the KYTC Standard Specifications and the latest version of the KYTC Standard Drawings.
- B. Rock Channel Protection (Riprap): Per the latest version of the KYTC Standard Specifications and as indicated on the Drawings.

# PART 3 - EXECUTION

## 3.1 EARTHWORK

- A. General:
  1. Conduit Under Pavement: Refer to KYTC Standard Specifications Item 701.02.
  2. Conduit Not Under Pavement: Refer to KYTC Standard Specifications Item 701.02.
- B. Excavation For Utility Trenches:
  1. Excavate trenches to indicated slopes, lines, depths, and invert elevations.
  2. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit.
  3. Excavate trench walls per KYTC Standard Specifications Item 701.03 and geotechnical report as identified on the Drawings.
  4. Where encountering rock or another unyielding bearing surface, carry trench excavation 6 inches below invert elevation to receive bedding course.

C. Utility Trench Backfill:

1. Place and compact bedding course as required by KYTC Standard Specifications Item 701.03.03 and geotechnical report. Type 2 bedding consists of structural backfill extending at least 3 inches (75 mm) for all KYTC Item 810 rigid pipe conduits and 6 inches (150 mm) for all other conduits below the bottom of the conduit for the full width of the trench. Extend the bedding up around the pipe for a depth of not less than 30 percent of the rise of the conduit. Shape the bedding to fit the conduit with recesses shaped to receive the bell of bell-and-spigot pipe. Leave the bedding below the middle one-third of the pipe span uncompacted. Compact the remaining bedding according to KYTC Standard Specifications Item 701.03.03.
2. Use Type 2 bedding for Types A, B, C, and D conduits except for long span structures and for conduits that require Type 3 bedding.
3. Type 3 bedding consists of a natural foundation with recesses shaped to receive the bell of bell-and-spigot pipe. Scarify and loosen the middle one-third of the pipe span.
4. Use Type 3 bedding for Type C and Type D conduits of the following materials: KYTC Items 810.03.
5. Structural backfill for KYTC Item 701 bedding and backfill shall consist of limestone, gravel, natural sand, sand manufactured from stone, or foundry sand. Provide Type I or Type II structural backfill per the requirements of KYTC Item 701.02.
6. Non-structural backfill should consist of clean, inorganic soil free of any miscellaneous materials, cobbles, and boulders. The fill should be placed in uniform, thin lifts and carefully compacted to a unit dry weight equal to 100 percent in structure areas and at least 98 percent of the maximum dry weight below pavement areas. The moisture content of the fill should be maintained at -2 to +1 percent of the optimum moisture content as determined in the laboratory by the Standard Test Methods for Moisture-Density Relations of Soils (ASTM D 698). Fill should not be placed in a frozen condition or upon a frozen subgrade.
7. Place backfill to the limits described and according to the compaction requirements of KYTC Item 701.02. Place the backfill in the trench and embankment outside the trench uniformly on both sides of the conduit for all conduit installations.
  - a. Type A and B. Backfill Types A and B conduits except for long span structures as follows
    - 1) In a cut situation, place and compact structural backfill above the bedding for the full depth of the trench. Within the trench and more than 4 feet (1.2 m) above the top of the conduit, if the trench can accommodate compaction equipment, the Contractor may construct Item 203 Embankment. For plastic pipe with an ID 8 inch (200 mm) or less, place and compact structural backfill above the bedding for the full depth of the trench.
    - 2) In a fill situation, place and compact structural backfill above the bedding for the full depth of the trench specified in 603.05.B. Above these limits, uniformly place the lesser of one pipe span or 4 feet (1.2 m) of structural backfill on each side of the conduit and to a depth of 2 feet (0.6 m) above the top of the conduit. Construct the embankment outside the limits of the backfill. For plastic pipe with an ID 8 inch (200 mm) or less, place and compact structural backfill above the bedding for the full depth of the trench.
  - b. Type C and D. Backfill Type C and D conduits as follows:
    - 1) In a cut situation, for plastic pipe, place and compact structural backfill above the bedding and to 12 inches (300 mm) over the top of the pipe. All other conduit material types place and compact backfill. For plastic pipe with an ID 8 inch (200 mm) or less, place and compact structural backfill above the bedding for the full depth of the trench.
    - 2) In a fill situation, for plastic pipe, place and compact structural backfill above the bedding for the full depth of the trench specified in 603.05.B. Above these limits, uniformly place the lesser of one pipe span or 4 feet (1.2 m) of structural backfill on each side of the conduit and vertically to the top of the conduit. Then place for a depth of 12 inches (300 mm) structural backfill

over the top of the pipe equal to the trench width centered on the pipe center line. Construct the embankment outside the limits of the backfill. All other conduit material types place and compact backfill. For plastic pipe with an ID 8 inch (200 mm) or less, place and compact structural backfill above the bedding for the full depth of the trench.

8. Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
9. All fill soils shall be placed in accordance with the article "Compaction of Soil Backfills and Fills" from the Earth Moving Specification Section 312000.
10. Coordinate backfilling with utilities testing.
11. Fill voids with approved backfill materials as shoring and bracing, and sheeting is removed.
12. Place and compact final backfill of satisfactory soil material to final subgrade.

### 3.2 PIPING INSTALLATION

- A. All installation shall be per the latest version of KYTC Standard Specifications item 701.03.04 and the latest version of the KYTC Standard Drawings.
- B. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, contact architect.
- C. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
- D. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- E. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- F. Install gravity-flow, non-pressure drainage piping according to the following:
  1. Install piping pitched down in direction of flow, at minimum slope of 1 percent, unless otherwise indicated.
  2. Install piping with 12 inches minimum cover, unless otherwise indicated on the drawings. Notify architect if less than 12 inches of cover will exist.
  3. During construction protect installed piping from damage. Maintain manufacturers recommended minimum cover.

### 3.3 PIPE JOINT CONSTRUCTION

- A. All joint construction shall be per the latest version of KYTC Standard Specifications item 701.03.05 and the latest version of the KYTC Standard Drawings.
- B. Join dissimilar pipe materials with pressure-type couplings, or concrete collar.

### 3.4 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
  - 1. Use medium-duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
  - 2. Use heavy-duty, top-loading classification cleanouts in paved foot-traffic, vehicle-traffic, roads, and service areas.
- B. Set cleanout frames and covers in earth in cast-in-place concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding earth grade.
- C. Set cleanout frames and covers in asphalt or concrete pavement with tops flush with pavement surface.

### 3.5 DRAIN INSTALLATION

- A. Install type of drains in locations indicated.
  - 1. Use medium-duty, top-loading classification drains in earth or unpaved foot-traffic areas.
  - 2. Use heavy-duty, top-loading classification drains in paved foot-traffic, vehicle-traffic, roads, and service areas.
- B. Install per manufacturer's written recommendations.

### 3.6 MANHOLE INSTALLATION

- A. General: Installation shall be per the latest version of the KYTC Standard Specifications and the latest version of the KYTC Standard Drawings.
- B. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere, unless otherwise indicated.

### 3.7 CATCH BASIN INSTALLATION

- A. General: Installation shall be per the latest version of the KYTC Standard Specifications and the latest version of the KYTC Standard Drawings.
- B. Set frames and grates to elevations indicated.

### 3.8 STORMWATER INLET AND OUTLET INSTALLATION

- A. General: Installation of Headwalls and Rock Channel Protection shall be per the latest version of the KYTC Standard Specifications and the latest version of the KYTC Standard Drawings.

### 3.9 CONCRETE PLACEMENT

- A. Place cast-in-place concrete according to ACI 318/318R.

**3.10 CONNECTIONS**

- A. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Division 22 Section "Facility Storm Drainage Piping."

**3.11 FIELD QUALITY CONTROL**

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
  - 1. Defects requiring correction include the following:
    - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    - c. Crushed, broken, cracked, or otherwise damaged piping.
  - 2. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
  - 3. Reinspect and repeat procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
  - 1. Do not enclose, cover, or put into service before inspection and approval.
  - 2. Test completed piping systems according to authorities having jurisdiction.
  - 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
- C. Replace defective piping using new materials, and repeat testing until defect is within allowances specified.

**3.12 CLEANING**

- A. Clean interior of piping of dirt and superfluous materials.

**END OF SECTION 334100**

**SECTION 334600 - SUBDRAINAGE****PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

**1.2 SUMMARY**

- A. This Section includes subdrainage systems for the following:
  - 1. Foundations.
  - 2. Underslab areas.
  - 3. Plaza decks.
  - 4. Retaining walls.
  - 5. Landscaped areas.

**1.3 DEFINITIONS**

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. HDPE: High-density polyethylene plastic.
- C. PE: Polyethylene plastic.
- D. PP: Polypropylene plastic.
- E. PS: Polystyrene plastic.
- F. PVC: Polyvinyl chloride plastic.
- G. Subdrainage: Drainage system that collects and removes subsurface or seepage water.

**1.4 SUBMITTALS**

- A. Product Data: For the following:
  - 1. Perforated-wall pipe and fittings.
  - 2. Solid-wall pipe and fittings.
  - 3. Drainage conduits.
  - 4. Geotextile filter fabrics.

## **PART 2 - PRODUCTS**

### **2.1 PIPING MATERIALS**

- A. Refer to the "Piping Applications" Article in Part 3 for applications of pipe, fitting, and joining materials.

### **2.2 PERFORATED-WALL PIPES AND FITTINGS**

- A. Perforated PE Pipe and Fittings: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
  - 1. Couplings: Manufacturer's standard, band type.
- B. Perforated PVC Sewer Pipe and Fittings: ASTM D 2729, bell-and-spigot ends, for loose joints.

### **2.3 SOLID-WALL PIPES AND FITTINGS**

- A. Cast-Iron Soil Pipe and Fittings: ASTM A 74, Service and Extra-Heavy classes, hub-and-spigot ends, gray, for gasketed joints.
  - 1. Gaskets: ASTM C 564, rubber, of thickness matching class of pipe.
- B. PE Drainage Tubing and Fittings: AASHTO M 252, Type S, corrugated, with smooth waterway, for coupled joints.
  - 1. Couplings: AASHTO M 252, corrugated, band type, matching tubing and fittings.
- C. PVC Sewer Pipe and Fittings: ASTM D 3034, SDR 35, bell-and-spigot ends, for gasketed joints.
  - 1. Gaskets: ASTM F 477, elastomeric seal.

### **2.4 SPECIAL PIPE COUPLINGS**

- A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant metal tension band and tightening mechanism on each end.
  - 1. Unshielded Flexible Couplings: Elastomeric sleeve with corrosion-resistant metal tension band and tightening mechanism on each end.
  - 2. Shielded Flexible Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant metal tension band and tightening mechanism on each end.

### **2.5 CLEANOUTS**

- A. Description: ASME A112.36.2M, round, cast-iron housing with clamping device and round, secured, scoriated, cast-iron cover. Include cast-iron ferrule with inside calk or spigot

connection and countersunk, tapered-thread, brass closure plug. Use units with top-loading classifications according to the following applications:

- B. Light Duty: In earth or grass, foot-traffic areas.
- C. Medium Duty: In paved, foot-traffic areas.
- D. Heavy Duty: In vehicle-traffic service areas.
- E. Extra Heavy Duty: In roads.
- F. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, service class, cast-iron soil pipe and fittings.

## 2.6 SOIL MATERIALS

- A. Backfill, drainage course, impervious fill, and satisfactory soil materials are specified in Division 31 Section "Earth Moving."

## 2.7 GEOTEXTILE FILTER FABRICS

- A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.
  - 1. Structure Type: Nonwoven, needle-punched continuous.
  - 2. Style(s): Flat.

# PART 3 - EXECUTION

## 3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

## 3.2 PIPING APPLICATIONS

- A. Underground Subdrainage Piping:
  - 1. Perforated PE pipe and fittings, couplings, and coupled joints.
  - 2. Perforated PVC sewer pipe and fittings for loose, bell-and-spigot joints.
- B. Underslab Subdrainage Piping:
  - 1. Perforated PE pipe and fittings, couplings, and coupled joints.
  - 2. Perforated PVC sewer pipe and fittings and loose, bell-and-spigot joints.

### 3.3 FOUNDATION DRAINAGE INSTALLATION

- A. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 inches deep and 12 inches wide.
- B. Place impervious fill on subgrade adjacent to bottom of footing and compact to dimensions indicated, but not less than 6 inches deep and 12 inches wide after concrete footing forms have been removed.
- C. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- D. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches.
- E. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive.
- F. Install drainage piping as indicated in Part 3 "Piping Installation" Article for foundation subdrainage.
- G. Add drainage course to width of at least 6 inches on side away from wall and to top of pipe to perform tests.
- H. After satisfactory testing, cover drainage piping to width of at least 6 inches on side away from footing and above top of pipe to within 12 inches of finish grade.
- I. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
- J. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches.
- K. Place initial backfill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches. Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.

### 3.4 UNDERSLAB DRAINAGE INSTALLATION

- A. Excavate for underslab drainage system after subgrade material has been compacted but before drainage course has been placed. Include horizontal distance of at least 6 inches between drainage pipe and trench walls. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
- B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches.
- D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive.
- E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for underslab subdrainage.

- F. Add drainage course to width of at least 6 inches on side away from wall and to top of pipe to perform tests.
- G. After satisfactory testing, cover drainage piping with drainage course to elevation of bottom of slab, and compact and wrap top of drainage course with flat-style geotextile filter fabric.

### 3.5 PIPING INSTALLATION

- A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.
  - 1. Foundation Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of **36 inches**, unless otherwise indicated.
  - 2. Underslab Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent.
  - 3. Lay perforated pipe with perforations down.
  - 4. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.
- B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
- C. Install PE piping according to ASTM D 2321.
- D. Install PVC piping according to ASTM D 2321.

### 3.6 PIPE JOINT CONSTRUCTION

- A. Cast-Iron Soil Pipe and Fittings: Hub and spigot, with rubber compression gaskets according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook." Use gaskets that match class of pipe and fittings.
- B. Join PE pipe, tubing, and fittings with couplings for soil-tight joints according to AASHTO's "Standard Specifications for Highway Bridges," Division II, Section 26.4.2.4, "Joint Properties."
- C. Join perforated, PE pipe and fittings with couplings for soil-tight joints according to AASHTO's "Standard Specifications for Highway Bridges," Division II, Section 26.4.2.4, "Joint Properties"; or according to ASTM D 2321.
- D. Join PVC pipe and fittings according to ASTM D 3034 with elastomeric seal gaskets according to ASTM D 2321.
- E. Join perforated PVC pipe and fittings according to ASTM D 2729, with loose bell-and-spigot joints.
- F. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

**3.7 CLEANOUT INSTALLATION**

- A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
- B. Set cleanout frames and covers in earth in a cast-in-place concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch (25 mm) above surrounding final earth grade.
- C. Set cleanout frames and covers in concrete paving with tops flush with surface of paving.

**3.8 CONNECTIONS**

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect low elevations of subdrainage system to building's solid-wall-piping storm drainage system.
- C. Where required, connect low elevations of foundation subdrainage to stormwater sump pumps.

**3.9 FIELD QUALITY CONTROL**

- A. Testing: After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

**3.10 CLEANING**

- A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

**END OF SECTION 334600**