SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Requirements for material handling, and other basic electrical materials and methods.

B. Related Sections:
   1. Division 01 Sections as Applicable
   2. Section 26 05 03 – Equipment Wiring Connections
   3. Section 26 05 05 – Selective Demolition for Electrical
   4. Section 26 05 19 - Low-Voltage Electrical Power Conductors
   5. Section 26 05 26 – Grounding and Bonding for Electrical Systems
   6. Section 26 05 28 – Hangers and Supports for Electrical Systems
   7. Section 26 05 33.13 – Conduits for Electrical Systems
   8. Section 26 05 33.23 – Boxes for Electrical Systems
   9. Section 26 05 53 – Electrical Identification
   10. Section 26 05 63 – Acceptance Testing of Electrical Systems
   11. Section 26 22 00 – Low-Voltage Transformers
   12. Section 26 24 16 - Panelboards
   13. Section 26 27 26 - Wiring Devices.
   14. Section 26 28 16.13 – Low Voltage Enclosed Switches
   15. Section 26 50 00 – Lighting
   16. Section 27 00 00 - Communications

1.02 REFERENCES

A. America National Standards Institute (ANSI):
   1. ANSI Z535.4, Product Safety Signs and Labels.

B. American Society of Mechanical Engineers (ASME):
   1. ANSI/ASME Y14.2M, Line Conventions and Lettering.
   2. ANSI/ASME Y14.24M, Types and Applications of Engineering Drawings.
   3. ANSI/ASME Y14.34M, Associated Lists.
   4. ANSI/ASME Y14.35M, Revision of Engineering Drawings and Associated Documents.
   5. ANSI/ASME Y14.100, Engineering Drawing Practices.

C. Institute of Electrical and Electronic Engineers (IEEE):

1. ANSI/IEEE C37.13, Low-Voltage AC Power Circuit Breakers Used in Enclosures.
2. ANSI/IEEE C57.12.59, Standard for Dry-Type Transformer Through-Fault Current Duration

D. InterNational Electrical Testing Association, Inc. (NETA):
   1. ANSI/NETA ETT Standard for Certification of Electrical Testing Technicians.

E. National Electric Manufacturer's Association (NEMA).
   1. NEMA ICS 6, Industrial Control and Systems: Enclosures.

F. National Electrical Contractors Association (NECA)
   1. ANSI/NECA 100 Symbols for Electrical Construction Drawings.

G. National Fire Protection Association (NFPA):
   1. NFPA 70, National Electrical Code (NEC).
   2. NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces.

H. The Society for Protective Coatings (SSPC):
   1. SSPC-SP 2, Hand Tool Cleaning.

1.03 SUBMITTALS

A. Submit the following information for approval in accordance with the requirements of Section 01 33 00, Submittal Procedures:
   1. Product Data:
      a. Submit Product Data, including catalog cuts, for all products provided for the electrical work of this Contract and as specified in other Sections.
         1) Clearly indicate the specific products proposed for the project by use of arrow, circle or underline. Indicate usage of each product on each submittal.
   2. Shop Drawings:
      a. Submit Shop Drawings for the electrical work of this Contract as specified in other Sections.
   3. Quality Assurance/Control Submittals:
      a. Certificates:
         1) Testing agency quality verification that all products meet requirements or manufacturer disclaimer statements.
      b. Qualification Statements:
         1) Testing agency qualifications.
   4. Closeout Submittals:
      a. Operation and Maintenance Manuals.

1.04 SUBSTITUTIONS, BASIS OF DESIGN, AND ACCEPTABLE MANUFACTURERS

A. All substitutions to identified materials or equipment shall comply with the applicable requirements of Division 1. In any case of conflict between such requirements of Division 1 and this paragraph, the more stringent requirements shall govern.

B. Whenever an item of material or equipment is identified by using the name of a proprietary item or the name of a particular supplier, the specification or description is intended to establish the type, function and quality required. Unless the identification or description contains or is followed by words reading that no like, equivalent or "or-equal" item or no substitution is permitted, material or equipment of other Suppliers may be proposed.

C. Where substitutions to identified items are permitted, any proposed substitution or alternate must fully comply with the following in order to be considered by the Engineer:
   1. Be of a reputable manufacturer,
   2. Be fully compliant with the requirements of this Section and the Drawings,
   3. Be fully compatible with all interfacing items and work, and with the installation environment,
   4. Be appropriate (as determined by the Engineer) for the proposed application, and
   5. Be equivalent (as determined by the Engineer) in character, performance, and quality to any identified Basis of Design.

D. Where a specific manufacturer or product is identified as the Basis of Design or listed first in a list of acceptable manufacturers, the overall project design is based on the identified manufacturer or product. If the Contractor elects to substitute a manufacturer or product which differs from the identified Basis of Design, the Contractor shall bear all efforts and costs of any design changes necessary in order to achieve finished work which is equal in character, performance, and quality to the original design depicted in the Contract Documents. Such changes shall include, but not necessarily be limited to: changes to ratings and/or features of other equipment, changes to material sizes and/or types, new material and/or equipment, and changes to structural and/or architectural features (including room sizes). Approval by the Engineer of a proposed substitute item shall not relieve the Contractor of this responsibility.

E. The listing of specific manufacturers is solely intended to identify reputable manufacturers who are known to provide quality products of the general type specified. Such listing is in no way intended to imply that the identified manufacturers product(s) have been verified to satisfy the specified requirements, or to be equivalent to any identified Basis of Design manufacturer. Nor does such a listing imply acceptance of products which do not meet the specified requirements, ratings, features, dimensions, and functions as indicated.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Testing Agency Qualifications:
      a. Use a NETA accredited testing agency, or approved equal, that is accredited for the region in which the Contract work is performed.
      b. Submit the testing agency's qualifications to the Engineer for approval.

B. Regulatory Requirements:
   1. Perform all electrical work in conformance with the requirements of NFPA 70, the National Electrical Code.

C. Certifications:
   1. Submit evidence with all Product Data that the products represented meet testing agency quality verification requirements, including agency listing and labeling requirements.
      a. Such evidence may consist of either a printed mark on the data or a separate listing card.
      b. Submit a written statement from those product manufacturers that do not provide evidence of the quality of their products that indicates why an item does not have quality assurance verification.
         1) Such statements provided in lieu of quality assurance verification are subject to the acceptance of the Owner and the Engineer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials and equipment to the work site in accordance with the requirements of Division 01.
   1. Deliver materials and equipment in a clean condition.
      a. Provide packaging that plugs, caps, or otherwise seals openings both during shipping and temporary storage.
   2. Provide equipment needed for unloading operations and have such equipment on the work site to perform unloading work when the material and equipment is delivered.
      a. If possible, clearly identify pick-points or lift-points on electrical equipment crating and packaging.
      b. In the absence pick-points or lift-points on equipment crating and packaging, identify pick-points or lift-points on the equipment itself.

B. Handle materials and equipment in accordance with the requirements of Division 01.
   1. Handle materials and equipment in accordance with manufacturer's written instructions.
   2. When unloading materials and equipment, provide special lifting harnesses or apparatus as required by manufacturers.

C. Store electrical materials and equipment, whether on-site or off-site, in accordance with Division 01 and the following:
   1. Follow the manufacturer's written instructions for storing the items.
   2. Store electrical equipment and products under cover.
      a. Except for electrical conduit, store electrical equipment and products in heated warehouses or enclosed buildings with auxiliary heat and that provide protection from the weather on all sides.

1.07 SYSTEM STARTUP

A. Energize the following items in the presence of the Engineer:
   1. Process instrumentation.
   2. Equipment rated over 300 Volts.
   3. Equipment rated over 1-horsepower.

B. Startup the following items in the presence of the Engineer:
   1. Instrumentation.
   2. Process equipment.

1.08 MAINTENANCE

A. Operation and Maintenance Manuals:
   1. Prepare Operation and Maintenance Manuals in conformance with the requirements of Division 01, other Contract requirements, and as follows:
      a. Organize Operation and Maintenance Manuals by Specification Section and equipment number as designated on the Contract Drawings.
      b. Include suppliers, supplier addresses, and supplier telephone numbers for the equipment and products furnished.
   2. 60 days prior to the request for final payment, prepare and submit two copies of the proposed Operation and Maintenance Manuals to the Engineer for approval.
   3. Upon approval of the proposed Operation and Maintenance Manuals, submit six corrected copies as follows:
      a. Submit one set to the Engineer.
      b. Place one set in the spare parts and fuse cabinet in the new electrical service building
      c. Deliver the remaining four copies to the Owner.
   4. Insert final record drawings in each set of Operation and Maintenance Manuals at Project Closeout.

PART 2 PRODUCTS

2.01 MATERIALS
   1. Specified within individual specification sections.

2.02 SHOP FINISHING

A. For electrical equipment, factory-apply paint and coating systems that at a minimum meet the requirements of the NEMA ICS 6 corrosion-resistance test and the additional requirements specified in individual Specification Sections.

PART 3 EXECUTION

3.01 INSTALLATION

A. Field-Applied Finishes:
   1. Except for factory-finished items that have been completely finished with factory-applied primer and final finish coatings, finish installed electrical materials, equipment, apparatus, and items in the field in accordance with the requirements of Section 09 90 00.
      a. Apply paint material matching the composition of the factory-applied products.
         1) Obtain factory-supplied paint for this work whenever available.
      b. Comply with the paint manufacturer's instructions for mixing, thinning, surface preparation, application, spreading rate, drying time, and environmental limitations concerning application of the paint.
      c. Apply paint in such a manner so that the finished appearance will match as nearly as possible the factory finish.
         1) Poorly applied paint may be required to be repaired and re-applied by the Contractor in accordance with Article 3.02 at no additional cost to the Owner.
   2. Coordinate the painting of large areas with the Engineer to minimize the duration of exposure of other workers to toxic paint fumes.

3.02 REPAIR/RESTORATION

A. If the factory finish of factory-finished items is damaged for any reason, refinish the item.
   1. If an item that has several surfaces has damage on one surface, refinish the entire damaged surface.
      a. Surface Preparation:
         1) Outside the damaged area, lightly sand the entire surface and perform additional sanding to profile the damaged paint edge.
         2) Prepare the surfaces of damaged areas in accordance with SSPC-SP 2.

3.03 FIELD QUALITY CONTROL

A. Perform electrical testing as detailed in Section 26 05 63 and in each Specification Section.

B. Have electrical work inspected as required by the local Authority Having Jurisdiction (AHJ).
   1. Submit a copy of the certification of inspection with the final project closeout documents, and post the original in the electrical room on-site protected by a metal frame with a protective plate glass cover.

C. The quality of finishing and refinishing work is subject to approval by the Engineer.

END OF SECTION

SECTION 26 05 03

EQUIPMENT WIRING CONNECTIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: The work specified in this Section consists of services and work of an administrative nature as well as general requirements concerning certain products and operations, all common to the entire Division 26 Sections.

B. Related Sections:
   1. Division 01 Sections as Applicable
   2. Division 11 Specifications
   3. Division 23 Specifications

1.02 ELECTRICAL INTERFACE

A. This Section of the Specifications is provided for clarification of the responsibilities of Division 26 with regard to the automatic temperature control wiring, safety disconnect switches, motor starters and variable frequency drives provided under Division 23.
   1. Energy management and automatic temperature control components, safety disconnect switches, motor starters and variable frequency drives which are furnished as part of Division 23 will be installed as work of Division 23. Such devices will be marked on the Electrical drawings as ‘by Division 23’.
   2. All 120 and 24 VAC wiring, including power wiring, conduit and final terminations, for energy management / automatic temperature control components shall be performed as work of Division 23.
   3. Division 26 shall be responsible for connecting power wiring to all safety disconnect switches, motor starters and variable frequency drives and from these control devices to the mechanical equipment. All control wiring for the variable frequency drives or motor starters shall be by Division 23.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Basic electrical materials required for the work to be included in this Section are as specified in other Sections of these Specifications and as shown on the Drawings.

2.02 COORDINATION

A. Electrical Equipment:
   1. Unless otherwise indicated, this Contractor will provide the required safety disconnect devices, motor starters, control relays, control stations, and all other

electrical appurtenances, as indicated on the Drawings, for the connection and operation of all electrical equipment included in this project.

B. Mechanical Equipment:
   1. Unless otherwise indicated, mechanical equipment control panel(s) will be provided as part of the work of other Contracts.
   2. Coordinate the installation of all field wiring with the respective Contract furnishing the equipment and with the approved shop drawings for the item being connected.
   3. Electrical Contractor will provide only power to respective control panel.
   4. Approved shop drawings indicating the required wiring connections will be provided by the respective Contract responsible for furnishing the equipment.

C. Bus Wash Equipment:
   1. Unless otherwise indicated, bus wash equipment control panels will be provided as part of the work of Division 11. These panels will generally contain the required starters for the associated AC and DC motors along with the control devices for the systems operation.
   2. Coordinate the installation of all field wiring with the respective Contract furnishing the equipment and with the approved shop drawings for the item being connected.
   3. Electrical Contractor will provide power and control wiring to the respective control panel as shown on the drawings. Connections shall be made within these control panels in collaboration with the bus wash equipment supplier to ensure a complete and operational system.

PART 3 EXECUTION

3.01 INSTALLATION

A. Electrical materials being installed for the connection of equipment shall be installed as specified in the applicable sections of these Specifications, and as indicated on the Drawings.

3.02 EQUIPMENT WIRING

A. General: Refer to the Drawings for the electrical field wiring required for this Contract.

B. Electrical and Mechanical Equipment Installation:
   1. Provide required wiring to items of equipment as indicated on the Drawings.

C. Bus Wash Equipment Installation:
   1. Provide required power and control interconnection wiring to items of equipment indicated.

2. Coordinate the installation of all field wiring with Division 11 furnishing the equipment and with the approved shop Drawings for the item being connected.
3. Provide interconnection wiring between bus wash control panels, control devices, and branch circuit panelboards as indicated and required for an operational system.
4. Approved Shop Drawings indicating the required wiring connections will be provided by Division 11 responsible for furnishing the equipment.

END OF SECTION

SECTION 26 05 05

SELECTIVE DEMOLITION FOR ELECTRICAL

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: The work specified in this Section consists of material for demolition and salvaging existing electrical systems, wiring, raceways, supports, equipment and minor repair of underlying structure.

B. Related Sections:
   1. Division 01 Sections, as Applicable

1.02 REFERENCES

A. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electrical Code (NEC)

1.03 SUBMITTALS

A. Submit demolition plan.

1.04 COORDINATION AND SEQUENCING

A. Coordinate all power outages with Owner.

B. Perform demolition in a manner not to delay or interfere with other operations of work in the Project and operations of the Owner.

1.05 SCHEDULING

A. Schedule all work with the Owner through the Owner’s designated representative. Start no work in an area until a schedule has been prepared, submitted and approved.

B. Coordinate the work schedule with the Owner, Engineer, and other Contractors. Coordinate the work so not to interfere or conflict with the performance of work by the Owner and the Owner’s tenants.

1.06 PROJECT/SITE CONDITIONS

A. Care shall be used so not to impede the ongoing work of any tenant.

B. Demolition work, as specified herein, is not intended to be performed as a wrecking operation but as work relative to the performance of the various construction operations of the Project.

C. Existing Conditions:
   1. Demolition information shown or otherwise indicated on the Drawings is based on visual field examination and existing record documents. While the information provided is believed to be correct, no assurance is implied relative to its total completeness or accuracy. Report discrepancies to the Engineer before disturbing existing installations.
   2. The Contractor hereby distinctly agrees that the Engineer nor the Owner is responsible for the correctness or sufficiency of the information given and after his own Site Investigation:
      a. That he must have no claim for delay or extra compensation or damage on account of the information given; and
      b. That he must have no claim for relief from any obligation or responsibility under the Contract with respect to the above stated stipulations.

D. Protection: Exercise care during demolition work to confine demolition operations to the areas as indicated on the Drawings. The physical means and methods used for protection are at the Contractor's option. However, the Contractor will be completely responsible for replacement and restitution work, of whatever nature, at no expense to the Owner.
   1. Additionally, if public safety is endangered during the progress of the demolition work, provide adequate protective measures to protect public pedestrian and vehicular traffic on streets and walkways.
   2. Conform signs, signals and barricades to requirements of Federal, State and local laws, rules, regulations, precautions, orders and decrees.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Basic Electrical Materials: Those products such as conduit, raceway, wire and cable, support devices, fasteners, and control devices as required for work of this Section are specified in other Sections.

B. Equipment along with machinery and apparatus, motorized or otherwise, used to perform the demolition may be chosen at the Contractor's discretion. However, the chosen equipment shall perform the work within the limits of the Contract requirements.

C. Patching Materials: Patching materials shall match, as nearly as practical, the existing material for each surface being patched.

PART 3 EXECUTION

3.01 INSPECTION

A. Verify that measurements and existing circuiting arrangements are as shown on Drawings.

B. Equipment, machinery and apparatus, motorized or otherwise, used to perform the demolition work may be used as chosen at the Contractor's discretion, but which will perform the work within the limits of the Contract requirements.

C. Verify that abandoned wiring and electrical equipment serve only the abandoned facility.

3.02 DEMOLITION

A. General: The means and methods of performing electrical demolition and removal operations are the sole responsibility of the Contractor, except as otherwise specified. However, equipment used, and methods of demolition and removal will be subject to approval of the Engineer.
   1. Remove, relocate and extend existing installations to accommodate new construction as indicated and/or as required.
   2. Remove exposed abandoned conduit systems, including abandoned conduit systems above accessible ceiling systems.
   3. Remove wiring in abandoned conduit systems to source of power supply.
   4. Maintain access to existing electrical installations, which remain active. Modify installations and provide access panels or plates as appropriate.
   5. Extend existing installations using materials and methods compatible with existing electrical installations, and as specified in other Sections of these Specifications.
   6. Wiring Devices:
      a. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduits serving them is abandoned and removed. Provide blank covers for abandoned outlets, which are not removed.
      b. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
   7. Lighting:
      a. Disconnect and remove abandoned luminaires and poles, lighting fixtures and floodlighting units. Remove brackets, stems, hangers and other accessories.
      b. Disconnect and remove abandoned concrete luminaire pole bases.
   8. Equipment:
      a. Disconnect and remove electrical equipment where so indicated on the Drawings.
      b. Disconnect and remove abandoned distribution equipment, panelboards, disconnect switches and motor starters as indicated on the drawings or as otherwise required due to the removal of associated equipment.

9. In exposed through-structure conduit locations, or where concealed conduits become exposed by penetrating a structural floor, wall or ceiling, the abandoned conduits must be cut below the finished structural surface in order to perform surface patching.

B. System De-activation: Prior to demolition and removal work, de-activate existing electrical systems as indicated.

C. Use means and methods for permanent disconnection, which render the remaining electrical systems and apparatus in conformity with NFPA 70.

D. Provide temporary wiring and connections to maintain existing systems in service during construction.
   1. Conform temporary wiring to the requirements of NEC Article 305, General Requirements.
   2. Temporary electrical service work as specified in Division 1, General Requirements.

E. Remove all wiring from disconnected circuits, feeders, and equipment unless otherwise specified or indicated. Remove all exposed raceways and related supports. Cut all exposed raceways flush with floor and plug.

F. Coordinate electrical power outages with requirements in Section 26 05 00.

G. General: The means and methods of performing electrical demolition and removal operations are the sole responsibility of the Contractor except as otherwise specified. Use equipment and methods that do not damage items to remain or salvaged and areas adjacent to demolition operations. Use methods that do not interfere with Owner's operations and which do not cause excessive dust. Remove debris as it accumulates.

H. Cutting: Perform cutting work of existing structure materials by such methods as will prevent extensive damage beyond the immediate area of cutting.

I. Debris Removal: Dispose of demolition debris off site in a lawful manner. Containerize or otherwise store debris as work is in progress.

J. Patching: After demolition and removal work is performed patch the existing structure as required to match surrounding finish and appearance including the appropriate surface decoration.

K. Abandoned Electrical Equipment and Apparatus: Existing electrical equipment and apparatus in or on the structures not claimed as salvage by the Owner shall become the property of the Contractor and may not be disposed of on the site but removed and disposed of in a lawful manner off-site.

L. Salvage: The Owner shall have the right to claim as salvage any items and materials removed under the work of this Section. Should such right of salvage be exercised by

the Owner, move and neatly store removed items on the site in a location agreeable to the Owner and in a manner approved by the Engineer.

END OF SECTION

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Requirements for furnishing, installing, connecting, energizing, testing, cleaning, and protecting low voltage cable, shielded cable, and accessories.

B. Related Sections:
   1. Division 01 Sections as Applicable
   2. Section 26 05 00 – Common Work Results for Electrical
   3. Section 26 05 26 – Grounding and Bonding for Electrical Systems.
   4. Section 26 05 53 – Identification for Electrical Systems.
   5. Section 26 05 63 – Acceptance Testing for Electrical Systems.
   6. Section 26 05 33.23 – Boxes for Electrical Systems

1.02 REFERENCES

A. American Society for Testing Materials (ASTM):
   1. ASTM B 8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

B. Institute of Electrical and Electronic Engineers (IEEE):
   1. IEEE 383 - Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations.
   2. IEEE 1202 - Standard for Flame-Propagation Testing of Wire and Cables.

C. National Electrical Manufacturer's Association (NEMA):
   1. NEMA WC 26/EEMAC 201 - Binational Wire and Cable Packaging Standard.
   2. ANSI/NEMA WC 57 - Standard for Control, Thermocouple Extension, and Instrumentation Cables.

D. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC).

E. Underwriter's Laboratories, Inc. (UL):
   1. UL 13 - Standard for Power-Limited Circuit Cables.
   2. UL 1569 - Standard for Metal-Clad Cables.
   3. UL 1581 - Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.03 DESIGN REQUIREMENTS

A. Conductors in Raceway and Conduit Systems:

1. Provide conduit systems for installing the wiring that is outside of equipment.
2. Except for raceway or conduit for control wires or where otherwise indicated on the Contract Drawings, design raceway and conduit systems so that the maximum number of low-voltage current carrying conductors (per NFPA 70, Article 310) in each raceway or conduit does not exceed three, plus a ground.

B. Cable Tension Design Requirements:
   1. Design conduit runs so that the tension limits set by the wire and cable manufacturers will not be exceeded.
      a. Provide additional pulling points as required to limit the tension to acceptable levels.

C. Product Data and Catalog Cuts:
   1. Submit low-voltage ground, power, and control wiring product data as listed below for the products provided as the Work of this Section; and clearly indicate the usage of each product on the data submitted.
      a. Wires and cables.
      b. Lugs.
      c. Connectors.
      d. Tapes.
      e. Pulling lubricant.

D. Use of Trade Names:
   1. The use of trade names within the Contract Documents is intended to establish the basis of design and to illustrate the constructability and level of quality required.
      a. The use of trade names is not intended to exclude other manufacturers whose products are equivalent to those named, subject to compliance with Contract requirements.

1.04 SUBMITTALS

A. Submit the following information to the Engineer for approval in accordance with the requirements of Section 01 33 00, Submittal Procedures:
   1. Product Data:
      a. Wires and cables.
      b. Lugs
      c. Connectors.
      d. Tape.
      e. Pulling lubricant.
   2. Quality Assurance/Control Submittals:
      a. Certificates.
         1) Testing agency/quality verification.
      b. Manufacturer’s Instructions.
         1) Cable manufacturer’s recommendations.
      c. Qualification Statements.
         1) Documented experience of the installing firm.

2) Qualifications of the licensed electricians supervising the Work.

1.05 QUALITY ASSURANCE

A. Qualifications:
1. Installer Qualifications:
a. To install the Work of this Section, employ the services of a firm specializing in installing wire, cable, and accessories, and that has a minimum of 3 years experience doing so.
1) Submit the documented experience of the firm installing the wire, cable, and accessories.
b. To supervise installation of the Work of this Section, employ licensed electricians.
1) Submit the qualifications of the licensed electricians supervising the Work of this Section.

B. Regulatory Requirements:
1. Perform the Work of this Section in accordance with the requirements specified in NFPA 70, and to all other applicable state, local, and national governing codes and regulatory requirements.

C. Certifications:
1. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory (ETL) for the location installed in, and the application intended, unless products meeting the requirements of these testing laboratories are not available or unless standards do not exist for the products.
a. Provide copper conductors listed and labeled by UL for all wiring.
2. Submit evidence of testing agency/quality verification, listing, and labeling for each product with the submitted product data either by providing a printed mark on the data or by attaching a separate listing card.
a. For items without such evidence, submit a written statement from the product manufacturer that indicates why it does not have quality assurance verification.

1.06 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
1. Imprint insulated conductors with the date of manufacture, the wire type, and the manufacturer.
2. Package wire and cable in conformance with the requirements of NEMA WC 26/EEMAC 201.
3. Protect items from damage during delivery, handling, and installation.
a. Comply with the cable manufacturer’s recommendations for inspection, handling, storage, temperature conditioning, bending and training limits, pulling limits, and calculation parameters for installing cable.

b. Submit the cable manufacturer's recommendations for inspection, handling, storage, temperature conditioning, bending and training limits, pulling limits, and calculation parameters for installing cable

B. Acceptance at Site:
1. Wire and cable manufactured more than 12 months before delivery to the Site is unacceptable for use under this Contract, and will be rejected.

C. Storage and Protection:
1. Store products indoors on blocking or pallets.
2. Protect items from damage during storage.

PART 2 PRODUCTS

2.01 LOW VOLTAGE CONDUCTORS

A. Conductor Design Requirements:
1. Provide conductors of the proper size and ampacity ratings based on Article 310 of NFPA 70.
a. Provide copper conductors that have 98 percent conductivity.
b. Unless otherwise indicated on the Contract Drawings, at a minimum provide conductors of the following American Wire Gauge (AWG) sizes:
1) For power and branch feeder circuits: 12 AWG.
a) For power and branch feeders, provide solid or stranded copper low-voltage conductors for sizes up to and including 10 AWG, provide stranded copper low-voltage conductors for 8 AWG and larger sizes.
2) For control circuits: 14 AWG.
3) For alarm and status circuits: 14 AWG.
4) For single conductor instrument wiring: 14 AWG.
5) For multiple conductor instrument wiring: 16 AWG.

B. Insulation Design Requirements:
1. Provide low voltage ground, power, and control wiring having the proper insulation types as follows:
a. For all locations: Type dual rated THHN/THWN.
2. Color Coding of Wires
a. Insulation shall be factory colored per Tables 26 05 19-1. The use of tape for color coding is prohibited.

C. Manufacturers
1. Acceptable Manufacturers:
a. Continental Wire & Cable Company
b. SouthWire
c. General Cable
a. CME Wire & Cable Inc.
b. Or Approved Equal

2.02 MATERIALS

A. Metal Clad Cable:
   1. Bare soft annealed copper conductors, solid or Class B stranded per ASTM B8. Conductors shall be solid copper in sizes up to and including No. 10 AWG. For sizes No. 8 AWG and larger, conductors to be stranded copper.
   2. Type THHN insulation, 600 volts, color coded.
   3. Insulated green copper grounding conductor. Meets or exceeds requirements of NEC Table 250-95.
   4. Assembled per UL 1569 with non-hygroscopic fillers and binder tape.
   5. Close fitting interlocked galvanized steel armor per UL 1569.
   6. UL listed as type MC cable.
   7. UL listed for cable tray use.
   8. Cable shall be suitable for environmental air handling space installation.
   9. Imprint insulated conductors with the date of manufacture, wire type, and manufacturer. Wire and cable manufactured more than 12 months before delivery to the job site shall not be used.
   10. The only permitted use of Metal Clad cable is for final whip-connections to lighting fixtures above suspended ceilings. Length shall not exceed 72 inches.
   11. Acceptable Manufacturers:
      a. AFC Cable Systems.
      b. Or Approved Equal.

2.03 ACCESSORIES

A. Cable Pulling Lubrication and Lubricant:
   1. Lubricant shall provide reduced tension on all types of cable jackets, dry to a thin lubricating film that retains its lubricity for an extended period and won't cement in the cables.
   2. The cable pulling lubricant shall produce a low coefficient of friction on a wide variety of cable jacket materials. The lubricant shall be UL listed. It shall be easy to handle and adhere well to the cable. Where appropriate, it shall also be tested and approved for use with CSPE (chlorosulfonated polyethylene) fire-retardant cable jackets where these materials are utilized.
   3. The lubricant shall be UL or CSA Listed and Labeled and shall pass the IEEE 1210, Standard Tests for Determining Compatibility of Cable-Pulling Lubricants with Wire and Cable. It shall pass physical compatibility tests on LLDPE, XLPE, CPE, and PVC cable jacket or sheath materials. It shall not stress crack polyethylene per ASTM Standard 1693. There shall be no significant changes in the conductive properties of XLPE and EPR semi-conducting compounds when the lubricant's effect on volume resistivity is tested according to IEEE Standard 1210.
   4. Lubricant to be specification-grade type that does not promote flame propagation when used with fire-retardant cables and systems, is harmless to humans, environmentally safe, and compatible with all common cable jacket materials

5. The lubricant shall contain no waxes, greases, silicones, or polyalkylene glycol oils or waxes. The lubricant shall have less than a 6.0% solids residue after drying for 24 hours at 105°C.
6. Where CPE insulated wire and/or cable is rated for Low Smoke / Zero Halogen type, only Polywater Type LZ shall be utilized.
7. Specific lubricants for fiber-optic and other special cable installations shall be determined by the cable / lubricant manufaturers and the Contractor shall provide submittal information, including MSDS documentation and other information verifying suitability of products and general specification compliance as outlined herein.
8. Acceptable Manufacturers:
   a. PolyWater - DynaBlue
   b. 3M - Type WL
   c. Greenlee - Type GEL

B. Grounding Braid:
   1. Provide conformable, all-metal (tinned copper wires), corrosion resistant, woven grounding braid having a high current-carrying capacity approximately that of 6 AWG wire, such as.
   2. Manufacturers:
      a. 3M, Scotch, Scotch® 25 Electrical Grounding Braid,
      b. Plymouth
      c. Permacel
      d. Approved equal.

C. Tapes:
   1. Arc Proofing Tape:
      a. Provide fire retardant arc proofing tape, such as Scotch® 77 Fire Retardant Electric Arc Proofing Tape, that is capable of protecting cables from fault arc generated heat and flames and of protecting adjacent wrapped cables and accessories exposed to fault arcs until limiting devices can interrupt the faulted circuit.
   2. Vinyl Insulating Tape:
      a. Provide UL-listed flexible polyvinyl chloride (PVC) backed insulating tape with a pressure sensitive adhesive, such as black Scotch® 33+ Vinyl Electrical Tape, that is resistant to abrasion, acids, alkalis, and copper corrosion; resistant to, hot, cold and wet weather; and resistant to damage from UV sunlight exposure.
   3. Rubber Splicing Tape:
      a. Provide highly conformable, linerless, self-bonding, ethylene rubber (EPR), high-voltage (through 69 kV) insulating tape formulated to provide excellent thermal dissipation of splice heat, and designed to insulate splices and terminate cables whose overload temperatures can reach 130 degrees Celsius, such as Scotch® 130C Linerless Rubber Splicing Tape.
   4. Manufacturers:

a. 3M, Scotch
b. Plymouth
c. Permacel
d. Approved equal.

D. Tubing:
1. Heat Shrinkable Tubing:
a. Provide flexible, flame retardant, polyolefin heat shrinkable thin wall tubing that has good resistance to common fluids and solvents, and has a high dielectric strength.
2. Waterproof Splice Kits:
a. Provide heat shrinkable thin wall polyolefin electrical cable splice kits.
3. Manufacturers:
a. Tyco Electronics, CGPT
b. Thomas & Betts Corp.
c. Approved equal.

E. Wire and Cable Connections:
1. Grounding Connectors:
a. Provide grounding connectors conforming to the requirements of Section 26 05 26 Grounding and Bonding for Electrical Systems.
2. Connectors for Service Wires and Cables, and for Wires and Cables Larger Than Number 6:
a. Split Bolt Connectors or Compression Type Connectors:
1) Provide UL-listed split bolt connectors or compression type connectors for making parallel or butt splices of stranded copper wire.
2) Use companion preformed plastic insulating covers or tape insulation conforming to NFPA 70 (NEC) requirements.
b. Mechanical compression connectors:
1) Provide mechanical compression connectors that are capable of connecting single or multiple conductors, and of being installed with one wrench.
a) Type: Compact, two-hole mechanical compression connectors having two clamping bolts.
(1) Connector Body: Provide a high copper bronze or brass alloy body.
(2) Bolts: Provide brass or bronze bolts; plated steel screws are unacceptable.
(3) Fasteners: Provide silicon-bronze fasteners for bolting connectors to connections.
c. Crimped Compression Connectors:
1) Provide two-hole crimped compression type connectors fabricated from high conductivity, seamless, electrolytic wrought copper, electrolytically tin-plated, and color coded to match the dies.

2) Provide crimped compression type connectors with adequate area to conduct the electrical current.
3) To crimp connectors, provide crimping tools from the same manufacturer that manufactured the connectors.

3. Control Wiring Connections:
   a. For control wiring connections at terminal boards, provide crimped nylon-insulated ring terminals.
   b. For control wiring splices, provide nylon insulated butt splices with insulation grips.
   c. For joining more than two control wires, provide junction boxes with terminal boards.
4. Instrumentation Cable Connectors:
   a. For connecting instrumentation cable and the equipment being furnished under this Contract, provide companion type connectors.
      1) For equipment controllers/enclosures that are furnished under other Sections of this Contract, furnish the connectors for connecting cable to the equipment with the equipment.
      2) Terminate the wiring as required for proper operation.
   b. Manufacturers:
      1) Thomas & Betts Corp.
      2) AMP Inc.
      3) Ilsco Corp.
      4) Ideal Industries, Inc.
5. Connectors for Other Conductors:
   a. Any of the applicable types listed for larger wire may be provided.
   b. Screw Terminal Connections:
      1) For making terminal connections of stranded copper wire to screw terminals, provide nylon insulated crimped compression terminals with copper barrel on the wire.
      2) For making terminal connections of solid copper wire to screw terminals, provide screw lock connectors.
   c. Wire Nuts:
      1) For making splices of copper wire, provide pre-insulated, UL-listed, solderless connectors of the spring-lock or compression type that can be installed by hand or using tools.
      2) For site lighting, wire nuts used in underground or below grade locations is prohibited. There only permitted use for site lighting is within a pole base.
   d. Manufacturers:
      1) Thomas & Betts Corp.
      2) Tyco Electronics, AMP Inc.
      3) Ilsco Corp.
      4) FCI-Burndy® Products
      5) Approved equal.

PART 3 EXECUTION

3.01 INSTALLERS

A. Install the work of this Section only under the supervision of licensed electricians.

3.02 EXAMINATION

A. Inspect all conduits, junction boxes, electrical vaults, and handholes to verify that they are clean, that they do not have burrs, that conduits are properly aligned, and that they are complete.
   1. Ensure that on all conduits without threaded hubs, two locknuts are installed.
   2. Ensure that in all conduits with wires larger than No. 10, bushings are installed.
   3. Ensure that grounding bushings and fittings are installed at all places specified in Section 26 05 26, Grounding and Bonding.
   4. Verify that proper sized boxes are installed.

B. Verify that boxes and conduit fittings conform to the bending requirements specified in Article 314 of NFPA 70 (NEC).

3.03 PREPARATION

A. Verify that pulling calculations have been made and are available for long conduit runs and pulls as indicated in this Section.

B. Do not begin installing wiring until other work which might cause damage to the wires, cables, or conduits has been completed.
   1. Correct deficiencies in conduits, junction boxes, electrical vaults, and handholes that have been discovered by the inspection required in Paragraph 3.02.A.

C. Prepare conduits to receive wire and cable.
   1. Swab the conduits with a nylon brush and steel mandrel.
   2. Pre-lubricate the conduits for which the pulling tension calculations are based on a coefficient of friction less than that of a dry conduit.

D. Verify that a means of controlling the pulling tension on the wire or cable is installed on the mechanical assist devices furnished for pulling cable.

E. Take the necessary precautions to prevent water, dirt, or other foreign material from accumulating in the conduits during the execution of wiring work.

3.04 INSTALLATION

A. Low Voltage Ground, Power, and Control Wiring:
   1. Install Type CL2P, FPLP, or CMP cable as required by the application in accordance with the requirements of NFPA 70 (NEC).
      a. For exposed low voltage wiring, use plenum cable.

b. For low voltage wiring concealed from view, only install wiring in the accessible locations permitted by the Contract Drawings.

2. Neutral Conductors:
   a. For each single-phase and each multi-phase feeder, provide separate neutrals.
   b. For branch circuits, except at three-phase wye-connected panelboards, provide separate neutral conductors.
      1) For the three-phyase wye-connected panelboards, provide common neutrals from 3 adjacent single-pole circuit breakers or from the poles of the same multi-pole circuit breaker.
   c. Except for feeders with a small unbalanced and single-phase load, size each neutral the same as the largest phase conductor.
      1) For feeders with a small unbalanced and single-phase load, size the feeders to the largest of the following:
         a) The size of any three-phase load connected to the neutral, which contains lighting, computer power outlets, instrumentation, or other electric loads.
         b) The size required for 125 percent of the maximum unbalanced load.
3. Equipment Ground Conductors:
   a. Provide a green equipment ground conductor with all runs.
      1) Provide the equipment ground conductor wire type as specified in Section 26 05 26, Grounding and Bonding.

B. Pulling Cable:
1. Establish a feed-in point at the manhole, handhole, or building located at the highest elevation of the run, and pull cables down grade using flexible cable feeds to convey the cables into the duct runs through the feed-in point opening.
   a. Furnish quadrant blocks located properly along the cable run.
   b. Limit cable pulling tensions to the maximum pulling tensions recommended by the cable manufacturer.
      1) Measure the cable pulling tension on all runs pulled with mechanical assistance and for all cable runs where calculations are required to be submitted by using a dynameter.
      2) Remove cables subjected to excessive bending and tension and that are cracked or have damaged or nicked outer jackets from the Site, and replace these cables with new undamaged cables.
         a) If pulling tension is exceeding during pulling, remove the affected cables and mark them as not to be reused.
   c. Lubricate cables with lubricants during pulling.

C. Terminating Cable:
1. Terminate cable using materials and methods indicated or specified herein, or in accordance with the written instructions of the cable manufacturer or termination kit manufacturer.
   a. For equipment connections, provide split bolt or compression type connectors, mechanical compression connectors, or crimped compression type connectors

as specified and approved by the equipment manufacturer; for all other types of connections provide connectors of one of the types specified:

2. Protect insulated power and lighting cable terminations from accidental contact, deterioration of coverings, and moisture by using proper terminating devices and materials.

D. Splicing Wire and Cable:
   1. All new conductors shall be continuous from end to end without splices, except where indicated on the drawings or with the special written permission of the Engineer on a case-by-case basis where the Contractor can demonstrate that installation without splices is not practical.
   2. If permitted as noted above, splice cables in accessible locations.
   3. Below-Grade Splices:
      a. In underground systems, locate splices above the 100 year flood level.
      b. Make below-grade splices using a compression connector on the conductor.
      c. Insulate and waterproof below-grade splices by methods suitable for continuous submersion in water using either of the methods that follow:
         1) Gravity Pour Method:
            a) Provide an approved commercial waterproof splice kit with the necessary materials and equipment, including a mold suitable for the cables to be spliced.
               (1) When the mold is in place around the joined conductors, prepare and pour the resin mix into the mold.
         2) Cast-Type Splice Insulation:
            a) Provide an approved commercial waterproof splice kit with the necessary materials and equipment, including a thermosetting epoxy resin insulating material applied by a gravity pour method or by a pressure injection method.
            b) Fix cables in place until the splicing materials have completely set.
   4. Within outlet or junction boxes, make wire and cable splices that conform to the requirements of NFPA 70 (NEC).
      a. Install these outlet or junction boxes in accessible locations.

E. Wiring Identification:
   1. Color code all feeder wires and cables as indicated in Table 26 05 19-1.

Table 26 05 19-1 Feeder Wire and Cable Color Coding

Phase	480Y/277 Volts	208Y/120 Volts
A	Brown	Black
B	Orange	Red
C	Yellow	Blue
Neutral	Gray or White with Yellow Tracer	White
Electrical Ground Conductor	Green	Green

2. Identify all power wiring by circuit and panelboard name/number.
3. Identify all control wiring with wire numbers.
4. Provide additional electrical identification of cabling and wiring as specified in Section 26 05 53, Identification for Electrical Systems.

3.05 FIELD QUALITY CONTROL

A. Site Tests:
   1. Prior to energizing wire and cable, field test the wire and cable as specified in Section 26 05 63 Acceptance Testing of Electrical Systems.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Requirements for connecting, energizing, testing, cleaning, and protecting grounding and bonding systems.

B. Related Sections:
   1. Division 01 Sections, as Applicable
   2. Section 26 05 00 – Common Work Results for Electrical.
   3. Section 26 05 63 – Acceptance Testing of Electrical Systems.
   4. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables
   5. Section 26 05 33.13 – Conduits for Electrical Systems.

1.02 REFERENCES

A. American Society for Testing Materials (ASTM):
   1. ASTM B 1; Standard Specification for Hard-Drawn Copper Wire.
   2. ASTM B 3; Standard Specification for Soft-Drawn Copper Wire.
   3. ASTM B 8; Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   4. ASTM C 653; Standard Guide for Determination of the Thermal Resistance of Low-Density Blanket-Type Mineral Fiber Insulation.
   5. ASTM D 5; Standard Test Method for Penetration of Bituminous Materials.
   6. ASTM D 149; Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
   7. ASTM D 257; Standard Test Methods for D-C Resistance or Conductance of Insulating Materials.
   8. ASTM D 570; Standard Test Method for Water Absorption of Plastics.

B. InterNational Electrical Testing Association, Inc. (NETA):
   1. ANSI/NETA ETT Standard for Certification of Electrical Testing Technicians.

C. National Fire Protection Association (NFPA):
   1. NFPA 70, National Electrical Code (NEC).

D. National Electrical Manufacturing Association (NEMA):
   1. NEMA TC-2; Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
   2. NEMA TC-3; Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.

3. NEMA TC-14; Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
4. NEMA WC-7; Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

E. Underwriter's Laboratories, Inc. (UL):
1. UL 467, Standard for Grounding and Bonding Equipment.
2. UL 486A-486B,Wire Connectors.
3. UL 486C, Standard for Splicing Wire Connections.
4. UL 486D, Standard for Insulated Wire Connector Systems for Underground Use or in Damp or Wet Locations.
5. UL 486E, Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.

1.03 DESIGN REQUIREMENTS

A. Design the electrical system installation to conform to Article 300 of NFPA 70, Wiring Methods, and to other applicable articles of NFPA 70 governing methods of wiring.

B. Ground the conduit systems, metal enclosures, equipment frames, motors, and receptacles in accordance with Article 250 of NFPA 70, Grounding.
1. Ground all metallic conduits, wiring channels, and armored cables continuously from outlet to outlet, and from outlets to cabinets, junction boxes, or pull boxes.
a. Bond each run of raceways to form a continuous path for ground faults from end to end.
b. When liquid tight flexible metal conduit sizes larger than 1-inch or flexible metal conduit are installed, provide external bond wires.
2. Grounding Bushings:
a. Provide all 1-inch or larger metallic conduits with grounding bushings unless they enter metallic enclosures via integral threaded hubs.
b. Provide grounding bushings for conduits entering the bottom of freestanding equipment.
c. Bond wire from every grounding bushing to the equipment ground stud or ground bus in the enclosure.
d. Bond the grounding bushings to ground studs or ground buses in the enclosures.
3. Provide insulated, internal equipment ground wire in all conduits.
a. Bond the internal wire to all pullboxes, junction boxes, equipment enclosures, and other enclosures as required by NFPA 70.

C. Equipment Grounds:
1. Design all feeders and branch circuits to include an equipment grounding conductor consisting of a copper wire within a raceway or cable and sized as specified herein.
a. Where conductors are run in parallel in multiple raceways, run the equipment grounding conductor in parallel to the related conductors.

b. Size each of the parallel equipment grounding conductors on the basis of the ampere rating of the circuit overcurrent protecting device.

2. Ground enclosing cases, mounting frames, rack mounted components, rack struts, switches, breakers, control panels, motors, and other electrical or electrically operated equipment by providing an equipment grounding conductor with phase conductors from an established equipment ground source.

D. Ground Wire Sizes:
1. The minimum size for bonding jumpers, equipment ground conductors, grounding electrode conductors, and ground grid conductors is as follows:
a. Under 600 volts:
1) Provide #12 AWG, minimum.
2) Control power circuits, Provide #14 AWG, minimum.
b. Over 600 volts:
1) For transformers, provide #2 AWG ground wire, minimum.
2) For motors, provide #4 AWG ground wire, minimum.
2. When the ground wire size is not specified or indicated on the Contract Drawings, provide wire sized in accordance with the requirements of NFPA 70.

E. Within 60 days of the Contract award, submit the following:
1. The Submittals required by Section 26 05 00.
a. Include Product Data and Catalog Cuts for all products provided, and describe the usage of each product.

F. Project Record Documents:
1. Prepare and submit record drawings showing the actual installed elevations and locations of grounding cables and rods for both concealed and exposed work provided under this Contract.

G. Project Closeout:
1. Submit Operation and Maintenance Manuals that include the record drawings and all Product Data in accordance with Division 01.

1.04 SUBMITTALS

A. Submit the following information for approval in accordance with the requirements of Division 01:
1. Product Data:
a. Manufacturer’s product data
2. Shop Drawings:
a. Underground Warning Tape
3. Quality Assurance/Quality Control Submittals:
a. Certificates:
1) Testing agency product certification
b. Qualification Statements:
1) System installers’ qualifications

2) Installation supervisors' resumes
4. Closeout Submittals:
   a. Operation and Maintenance Manuals

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Installer Qualifications:
      a. Employ installers who specialize in the work of this Section, and who can demonstrate a minimum of three years documented experience.
      b. Submit the system installers' qualifications.
   2. Supervisor's Qualifications:
      a. Employ supervisor to supervise the installation work who are skilled licensed electricians.
      b. Submit the installation supervisors' resumes.
   3. All products are to be certified by Underwriters Laboratories, Inc. (UL),

B. Regulatory Requirements:
   1. All grounding and bonding Work must comply with the requirements of NFPA 70, the National Electrical Code.

C. Certifications:
   1. Testing Agency Product Certification:
      a. Verify product quality by certifying products as meeting the requirements of one of the following:
         1) Underwriters Laboratories, Inc. (UL).
            a) Provide products listed and labeled by UL.
      b. Testing agency product certification must include agency listing and labeling, either by a printed mark on the data or by a separate listing card.
         1) If an item does not have this quality assurance verification, provide a written statement from the product manufacturer indicating why not; such manufacturer's statements are subject to the approval of the Owner and the Engineer.

1.06 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
   1. Transport materials, both on site and from Contractor's storage to site, in accordance with the recommendations of the respective manufacturers.

B. Storage and Protection:
   1. Store materials, both on and off site, in accordance with manufacturer's written instructions.
   2. Store products indoors on blocking or pallets.

PART 2 PRODUCTS

2.01 UNDERGROUND WARNING TAPE

A. Metal detectable polyester material, with minimum one-inch high lettering. Overcoated graphics to read, "CAUTION-BURIED ELECTRIC LINE" for electric lines, “CAUTION - BURIED TELEPHONE” for telephone lines and/or “CAUTION - BURIED FIBER-OPTIC CABLES” for fiber-optic lines. APWA color to be red for electric lines and orange for telecommunication or fiber-optic lines.

B. Acceptable Manufacturers:
   1. Brady
   2. LEM Products, Inc
   3. Seton
   4. Or Approved Equal

2.02 MATERIALS

A. Conduit and Conduit Fittings:
   1. For conduit and conduit fittings that enclose single ground wires without accompanying circuit conductors provide one of the following:
      a. Schedule 40, non-metallic conduit and fittings conforming to the requirements of NEMA TC-2, and the fittings additionally conforming to the requirements of NEMA TC-3.
   2. For other conduit and conduit fittings, provide conduit of the types specified or indicated and that conform to the requirements of Section 26 05 33.13.

B. Wire:
   1. Bare Ground Wire:
      a. Soft drawn copper, Class A or Class B stranded, meeting the requirements of ASTM B3 for sizes #6 or larger.
      b. Soft drawn solid copper, meeting the requirements of ASTM B3 for sizes #8 or smaller.
   2. Insulated Ground Wire:
      a. Provide insulated Class B copper stranded wire rated for 600 volts that conforms to the requirements of NEMA WC-7, and is green in color. Insulation type shall be as specified in Section 26 05 19.
   3. Acceptable Manufacturers:
      a. Continental Wire & Cable Company
      b. SouthWire
      c. General Cable
      d. Okonite Co.
      e. Or Approved Equal

C. Clamps and Non-Welded Connectors:

1. Provide bronze or brass clamps and connectors that are UL listed for use below grade.
    a. All bolts and other material must be bronze or brass, plated steel screws are unacceptable.
    b. Fabricate multi-bolt, solderless compression clamps from high strength electrical bronze, and provide silicon bronze clamping bolts and hardware.
2. Provide bolts, nuts, lock-washers, and similar hardware designed not to damage ground wire.
3. Acceptable manufacturers:
    a. Ilsco.
    b. Framatone Connectors Inc. (FCI), Burndy.
    c. Approved equal.

D. Exothermic Welding Kits:
1. Provide molds, thermite packages, and other material for exothermic welds that are rated to carry 100 percent of the cable ratings, and which are letter-coded exothermic welded type.
2. Provide all items such as tees, crosses, splices, and cable connections necessary for connecting ground and bonding cables to the following items:
    a. Ground rods.
    b. Reinforcing steel bars.
    c. Ground-bus.
    d. Structural steel.
    e. Water pipe.
    f. Bonding to the main-ground-grid.
    g. Bonding to Copper Grounding Bus Bar
3. Provide all exothermic welding molds, thermite packages, and other material used throughout the Work from a single manufacturer.
4. Acceptable Manufacturers:
    a. Erico, Cadweld®.
    b. Continental Industries, Inc., Thermoweld®.
    c. Approved equal.

E. Ground Rods:
1. Provide UL listed, sectional ground rods fabricated using a electrolytic plating process to copper clad a medium carbon steel core
2. Diameter: 3/4 inch.
3. Length: 10 feet.
    a. To obtain longer length rods, join rod sections using copper clad rod couplers.
4. Acceptable Manufacturers:
    a. Erico International Corp.
    b. Galvan Industries, Inc.
    c. South Atlantic, LLC
    d. A.B. Chance Co.

e. Or Approved Equal

PART 3 EXECUTION

3.01 EXAMINATION

A. Site Verification of Conditions:
1. The Contract Drawings are generally indicative of the Work, but due to their small scale, it is not possible to indicate some offsets and fittings required nor the minor structural obstructions that may be encountered.
a. Perform field measurements to discover offsets and fitting requirements not shown.
b. Locate all on-site utilities and other obstructions in the area of construction, and verify that interferences will not occur.

3.02 PREPARATION

A. Layout electrical work to suit actual field conditions and in accordance with accepted standard practice.

3.03 INSTALLATION

A. Perform required earthwork including excavation, backfill, and compaction, as specified in Division 31.

B. Construct each ground system and connection so it is mechanically secure and electrically continuous.
1. Secure grounds to boxes in such a manner that each system is electrically continuous from the point of service to each outlet.
2. Terminate conduits using double locknuts and bushings.
a. Unless a conduit run enters a metallic enclosure via integral threaded hubs, provide the conduit run with two locknuts.
3. Clean paint, grease and such other insulating materials from the contact points of grounds.

C. Equipment Ground Buses:
1. Whenever several pieces of equipment, other than service grounds, require external bond wires in an area, provide an equipment ground bus.
2. Wherever 5 or more conduits enter a box or enclosure, provide an equipment ground bus.
a. Connect all equipment ground wires and conduit bond wires within the box or enclosure to a single ground stud or single common ground bus.
3. Size ground buses to carry 100 percent of the rating or setting of the largest over current device in the circuit(s) ahead of the equipment, conduit, or other item, and as indicated on the Contract Drawings.

D. Equipment Grounds:
   1. Install equipment grounds in spaces accessible to authorized personnel only.
   2. Equipment Grounding Connectors:
      a. Only use approved grounding connectors.
         1) Terminate grounds with closed lugs with star washers on both sides and a 1/4-20 bolt and nut, minimum; spade lugs are not allowed.
         2) For portable electrical equipment, provide electric cords having an equipment grounding conductor and a NEMA and UL approved cord cap.
      b. Do not install grounding lugs on flanges, mounting screws, or standoffs in switches, distribution boxes, or panels.
      c. Cover or coat grounding clamps and connectors with coating compound.
   3. Equipment Grounding Conductors:
      a. Unless using multi-conductor cable, run equipment grounding conductors inside the same conduit or wiring channel enclosing the power conductors.
      b. In multi-conductor cable, locate grounding conductor inside the sheath or cable.
      c. Do not use a system neutral or a current carrying conductor as the equipment grounding conductor.
         1) Do not ground the electrical and electronic equipment neutral to chassis, racks, equipment ground conductor, or any non-current carrying conductor on the equipment.
   4. Grounding Lighting Fixtures:
      a. Provide the housing of each lighting fixture with a separate, factory-installed grounding device and ground conductor.
      b. Use the factory-installed grounding device for connecting a separate grounding conductor meeting applicable grounding requirements of the NEC to the fixture.
         1) Provide a green covered grounding conductor of the same wire gauge as the two power feed wires.
         2) Provide a continuous ground for the fixture construction.
   5. Grounding Motors:
      a. Install equipment grounding wire within conduit supplying power to motor.
      b. Install bonding connectors across the liquid tight flexible conduit supplying motors.
   6. Grounding and Bonding Pumps:
      a. Provide a bond from each pump to its motor using a conductor equal in size to the motor circuit equipment grounding conductors.
   7. Grounding Transformers:
      a. If a transformer is a separately derived system as defined in NFPA 70, provide a ground wire in both the primary and secondary conduits; and bond the ground wire and metallic conduits, if used, to the nearest effectively grounded metallic water pipe or nearest effectively grounded structural steel column.

b. Provide an additional bond between cold or hot water pipes and structural steel located near a transformer bond connection.

3.04 REPAIR/RESTORATION

A. Replace any finished exothermic welded splice connections that inspections find to be defective.

B. After inspection by Engineer and Owner's representative, backfill the direct buried cables and around ground rod protectors.
   1. Begin backfilling with clean washed sand to 6 inches above the ground rods or to the depth shown on the Contract Drawings, whichever is greater.
   2. Backfill using select fill in accordance with the requirements of Division 31.

C. Install underground warning tape above all buried cables/conduits at a depth of 12" below finished grade.

3.05 FIELD QUALITY CONTROL

A. Site Testing:
   1. Prior to energizing any system, test the resistance to ground for the system in accordance with Section 26 05 63.
      a. Perform a continuity test from all utilization and distribution equipment to the ground grid on a run-by-run basis.

B. Inspection:
   1. Prior to completion of the Work of this Section, inspect the items provided for conformity to the Contract Drawings and Specifications.
      a. Leave in-place "made grounds" open until they have been inspected and approved by the Engineer.
      b. Clean the surfaces involved in "made grounds" before connecting the grounds, and finish the installation with touch up painting or another protective coating to prevent corrosion.
   2. Inspect finished exothermic welded connections for the following defects:
      a. Conductors appear within the splice area.
      b. Top of splice risers are below conductors.
      c. Surfaces exhibiting more than 20 percent slag material.
      d. Surfaces with over slag material that has flowed into conductors.
      e. Mold blowouts.
      f. Excessive porosity.
         1) Small pores less than 1/32 inch are permitted.

3.06 PROTECTION

A. Protect finished insulated wires from being painted.

END OF SECTION

SECTION 26 05 28

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Requirements for furnishing, installing, cleaning, and protecting hanger and support systems for electrical wiring, conduit boxes, and equipment.

B. Related Section:
   1. Division 01 Sections, as Applicable
   2. Section 26 05 00 – Common Work Results for Electrical.

1.02 REFERENCES

A. American Iron and Steel Institute (AISI):
   1. AISI Standard Steels (Handbook).

B. American Society for Testing Materials (ASTM):
   1. ASTM A 36/A 36M - Standard Specification for Carbon Structural Steel.
   2. ASTM A 53/A 53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated - Welded and Seamless.
   3. ASTM A 123/A 123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   4. ASTM A 153/A 153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. ASTM A 283/A 283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
   6. ASTM A 325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi, Minimum Tensile Strength.
   7. ASTM A 500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   8. ASTM A 563 - Standard Specification for Carbon and Alloy Steel Nuts.
   9. ASTM A 575 - Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.
   10. ASTM A 576 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
   11. ASTM A 635/A 635M - Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot-Rolled.
   12. ASTM A 1011/A 1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.

13. ASTM B 633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
14. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

C. American Welding Society (AWS):
   1. AWS D1.1/D1.1M - Structural Welding Code - Steel.

D. National Electrical Manufacturers Association (NEMA):
   1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts maximum).

E. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC).
   2. NFPA 258 - Standard Research Test Method for Determining Smoke Generation of Solid Materials.

F. Society of Automotive Engineers International (SAE):
   1. SAE J 429 - Mechanical and Material Requirements for Externally Threaded Fasterners.

G. The Society for Protective Coatings (SSPC):
   1. SSPC Painting Manual.
      a. SSPC-SP 2 - Hand Tool Cleaning.
      b. SSPC-Paint 15 - Paint Specification No. 15, Steel Joist Shop Paint, Type I, Red Oxide Paint, Type II, Asphalt Coating.
      c. SSPC-Paint 20 - Paint Specification No. 20, Zinc-Rich Primers (Type I, “Inorganic,” and type II, “Organic”).

H. Underwriters Laboratory, Inc. (UL):
   1. UL 635 - Standard for Insulating Bushings.
   2. UL 870 - Standard for Wireways, Auxilliary Gutters, and Associated Fittings.
   3. UL 884 - Standard for Underfloor Raceways and Fittings.
   4. UL 1479 - Standard for Fire Tests of Through-Penetration Firestops.
   5. UL 2239 - Hardware for the Support of Conduit, Tubing, and Cable.

1.03 SUBMITTALS

A. Submit the following information to the Engineer for approval in accordance with the requirements of Division 01 and Section 26 05 00, Basic Electrical Materials and Methods:
   1. Product Data:
      a. Provide product data and catalog cuts for the products provided under this Section.
   2. Shop Drawings:
      a. Provide Shop Drawings.
      b. Provide Shop Drawings of hanging supports for conduit.

3. Quality Assurance/Control Submittals:
    a. Design Data:
        1) Provide structural calculations for the following items:
            a) Equipment backboards and support structures not directly fastened to the walls.
            b) Hanging supports for conduit.
        2) Detailed drawings of proposed departures from the original design.
    b. Certificates:
        1) Testing Agency/Quality Verification:
            a) With the product data for electrical hangers and supports, provide evidence of quality verification, listing, and labeling by the Electrical Testing Agency (ETA); either by a printed mark on the data, or by a separate listing card.
            b) If an item does not have ETA quality assurance verification, provide a written quality assurance verification statement from the product manufacturer indicating why the item does not have the specified quality assurance verification.
                (1) Such quality assurance verification statements are subject to approval by the Owner and the Engineer.
        2) Manufacturers' Certificate of Compliance.
    c. Qualification Statements:
        1) Manufacturers' qualifications.

1.04 QUALITY ASSURANCE

A. Qualifications;
    1. Electrical Testing Agency (ETA) Qualifications:
        a. Use the Electrical Testing Agency (ETA) qualified as specified in Section 26 05 00, Basic Electrical Materials and Methods.
    2. Manufacturers' Qualifications:
        a. Provide electrical support framing made by manufacturers that have been manufacturing support framing for a minimum of 5 years, and who carefully controls their operations to ensure that excellent product engineering, quality, safety, and reliability are achieved.
        b. Submit the manufacturer's qualifications to the Engineer for approval.

B. Certifications:
    1. Electrical Testing Laboratory (ETL) Certification:
        a. Provide products that are listed and labeled by Underwriters Laboratory, Inc. (UL) or certified as meeting the standards of UL by the Electrical Testing Laboratory (ETL) unless products meeting the requirements of these testing laboratories are not readily available or unless standards do not exist for the products.
    2. Manufacturers Certificate of Compliance:

a. Submit a manufacturer's Certificate of Compliance certifying that both the galvanizing and the products meet the requirements of the ASTM standards.

1.05 DELIVERY, STORAGE AND HANDLING

A. Packaging, Shipping, Handling, and Unloading:
1. Deliver, store, and handle the hangers and supports in accordance with Section 26 05 00 Common Work Results for Electrical, and as specified herein.
2. Deliver material to Site in the original factory packaging.

B. Storage and Protection:
1. Shelter and store the components under cover, and supported off the ground and floors on blocking.

PART 2 PRODUCTS

2.01 MATERIALS

A. Carbon Steel Shapes:
1. Provide shapes of the sizes specified and as indicated on the Contract Drawings:
2. Provide steel shapes complying with the following material specifications for the type of steel shape listed:
a. Steel Sections: ASTM A36/A 36M.
b. Steel Tubing: ASTM A 500, Grade B.
c. Plates: ASTM A 283/A 283M.
d. Sheets: ASTM A 1011/A 1011M.
e. Pipe: ASTM A 53/A 53M, Grade B, Schedule 40, hot-dipped, zinc-coated.

B. Welding materials:
1. Provide welding materials complying with the requirements of AWS D1.1/D1.1M for the type of material being welded.

2.02 MANUFACTURED UNITS

A. Metal U-Channel Electrical Support Framing Systems and Fittings:
1. Carbon Steel U-Channel Support Framing Systems:
a. Provide 1-5/8-inch nominal size U-channel supports fabricated from 12 gauge carbon steel electrolytically galvanized with a zinc-coating thickness commensurate with Service Condition SC 1 (mild) in conformance with the requirements of ASTM B 633.
1) For Type II ASTM B 633 galvanized finishes, fabricate the framing from steel complying with the requirements for Grade 33 specified in ASTM A 1011/A 1011M.
2) For Type III ASTM B 633 galvanized finishes, fabricate the framing from steel complying with the requirements of ASTM A 575, ASTM A 576, ASTM A 635/A 635M, or ASTM A 36/A 36M.

b. Where combination members are required, spot-weld the members on 3-inch centers.
c. Provide 1-3/8-inch or larger depths, except where supports are mounted directly to walls 13/16-inch or larger depths may be provided.
d. Provide metal framing systems and fittings for metal framing systems from a single manufacturer.
e. Manufacturers:
1) Unistrut Corporation, Unistrut® Metal Framing System
2) Thomas & Betts, Kindorf®
3) Cooper B-Line®, Inc.
4) Power-Strut
5) Approved Equal

B. Conduit Supports:
1. Malleable Iron Conduit Supports:
a. Provide one-hole style galvanized malleable iron fasteners with pipe straps similar to those as manufactured by Thomas & Betts.
b. Provide support devices consisting of threaded rods, channel supports, and conduit straps/fasteners.
2. Stamped Steel Conduit Supports:
a. Provide one-hole style galvanized stamped steel fasteners with pipe straps similar to those as manufactured by Thomas & Betts.
b. Provide support devices consisting of threaded rods, channel supports, and conduit straps/fasteners.
3. Manufacturers:
a. Thomas & Betts
b. Approved equal.

C. Cable Supports:
1. Provide voltage rated cable supports fabricated from hot-dip galvanized malleable iron with a threaded collar.
2. Provide tapered wedging cable plugs fabricated from hard fiber, impregnated hardwood, or canvas bakelite for the cable supports.
3. Manufacturers:
a. EGS Electrical Group, O-Z/Gedney, Inc., Type "M"
b. Approved equal.

D. Bolts, Nuts, and Washers:
1. For bolts, nuts, and washers smaller than 1/4-inch trade size, provide 316 stainless steel fasteners complying with the requirements of ASTM A 325.
2. For fastening galvanized components, provide galvanized bolts, nuts, and washers galvanized in accordance with the requirements of ASTM A 153/A 153M.

E. Anchors and Fasteners:
1. Drive (Deep-Pitch) Screws:

a. Provide Type 316 stainless steel self-tapping type drive (deep-pitch) screws that comply with the requirements of FF-S-107C(2).

2. Drilled-In Anchors and Fasteners:
   a. Provide drilled-in anchors and fasteners that comply with the requirements of FF-S-107C(2).
   b. Masonry Anchors:
      1) Provide masonry anchors designed to accept both machine bolts and threaded rods as fasteners.
         a) Provide SAE J 429 Grade 2 machine bolt fasteners fabricated from AISI Type 316 stainless steel.
         b) Provide nuts and washers conforming to the requirements of ASTM A 563.
      2) Provide masonry anchors consisting of an expansion shield and expander nut contained inside the shield.
         a) Expander Nuts:
            (1) Fabricate square expander nuts with their sides tapered inward from the bottom to the top.
            (2) Design the expander nuts to simultaneously climb the bolt or rod thread and expand the shield as soon as the threaded expander nut reaches and bears against the shield bottom when being tightened.
         b) Expansion Shields:
            (1) Provide expansion shield bodies consisting of four legs, the inside of each tapered toward the shield bottom, or nut end.
            (2) The end of one leg shall be elongated and turned across shield bottom. Outer surface of shield body shall be ribbed for grip-action.
      3) Masonry Anchor Material:
         a) Provide die cast Zamac No. 3 zinc alloy having a 43,000 psi minimum tensile strength.
      4) Manufacturers:
         a) U.S.E. Diamond, Inc., FORWAY System
   c. Concrete Anchors:
      1) Carbon Steel Anchor/Fastener:
         a) Provide UL listed one-piece studs (bolts) with integral expansion wedges, nuts, and washers.
         b) Provide carbon steel anchor/fasteners complying with the physical requirements specified in FF-S-325 for Group II, Type 4, Class 1.
      2) Stainless Steel Anchor/Fastener:
         a) Provide one-piece AISI Type 303 or 304 stainless steel studs (bolts) with integral expansion wedges, AISI Type 316 stainless steel nuts, and AISI Type 316 stainless steel washers.
         b) Provide stainless steel anchor/fasteners complying with the physical requirements of FF-S-325 for Group II, Type 4, Class 1.
      3) Acceptable Manufacturers:

a) U.S.E. Diamond, Inc.; SUP-R-STUD
b) Hilti Fastening Systems; KWIK-BOLT
c) Molly Fastener Group; PARABOLT.
d) Phillips; RED HEAD Wedge-Anchor

3. Hammer drive-type explosive charge drive-type anchors and fastener systems are unacceptable.
4. Lead shields, plastic-inserts, fiber-inserts, and drilled-in plastic sleeve/nail drive systems are unacceptable.

2.03 ACCESSORIES

A. Wall Seals:
1. Provide a hydrostatic seal to fill the annular space between conduit and through structure openings.
2. Manufacturer:
a. PSI-ThunderLine/Link-Seal Corp., Link-Seal®

B. Fire Seals:
1. Where conduit penetrates fire-rated walls, floors, partitions, and ceiling, provide approved fire seals to ensure that the fire rating is maintained.
2. Provide a fire seal system which is UL-listed for the application.
a. Provide fire seal compound or a mechanical seal for fire rating of 2 hours or less.
3. Manufacturers:
a. Compound Fire Seals:
1) Dow Corning Corporation
2) 3M
b. Mechanical Fire Seals:
1) PSI-ThunderLine/Link-Seal Corp.
c. Through-Wall Barrier Fire Seals:
1) Cooper Crouse-Hinds

2.04 FABRICATION

A. Fit and shop assemble items in the largest sections practical for delivery to the Site.

2.05 FINISHES

A. Prime paint non-galvanized steel items.
1. Prepare surfaces to be primed in accordance with the requirements of SSPC-SP 2.
a. Clean surfaces of rust, scale, grease, and foreign matter prior to finishing.
2. Prime Painting: Apply one coat of primer.

B. Galvanizing items specified above as galvanized.
1. Galvanize the items after fabrication in accordance with the requirements of ASTM A 123/A 123M.

2. Provide a minimum galvanized coating of 1.25 ounces per square foott (380 grams per square meter).

C. Touch-Up Primer:
   1. For un-galvanized metal surfaces: Provide primer complying with the requirements of SSPC-Paint 15 for Type I, Red Iron Oxide.
   2. For galvanized surfaces: Provide primer complying with the requirements of SSPC-Paint 20 for Type I, Inorganic Zinc-Rich Primer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Field Measurement:
   1. Although the Contract Drawings are generally indicative of the Work, take field measurements to verify actual conditions.
      a. Due to the small scale of the Contract Drawings it is not possible to indicate all offsets, fittings, and apparatus required or the minor structural obstructions that may be encountered during the Work.
   2. Carefully investigate the structural and finish conditions, and other construction work, at the Site which may affect the work of this Section.

3.02 PREPARATION

A. After carefully investigating structural and finish conditions and other in-place construction work, produce detailed Shop Drawings showing proposed departures from the original design due to field conditions or other causes.
   1. Layout the electrical work according to accepted standard electrical trade practice to suit actual field measurements.
   2. Arrange the electrical work to consider existing conditions and to preserve access to other equipment, rooms, areas, and similar features of the construction.
   3. Provide plan and profile views of duct banks, and show equipment backboards and support structures not directly fastened to the walls on the Shop Drawings.
   4. Indicate the location and details of conflicting utility construction and slopes on the Shop Drawings.
   5. Submit the Shop Drawings to the Engineer for approval prior to performing the Work of this Section.

B. Obtain roughing-in dimensions of electrically operated equipment, including equipment being installed by both electrical and other construction trades.
   1. Set conduit and boxes only after receiving approved dimensions and checking such equipment locations.
   2. Arrange electrical Work accordingly and furnish such fittings and apparatus as required to accommodate such conditions and to preserve access to other equipment, rooms, areas, and similar spaces.

3.03 INSTALLATION

A. Install electrical Work in conformance to the requirements of NFPA 70 for wiring methods general requirements, and to other applicable Articles of the NEC governing methods of wiring.

B. Installing Anchors and Fasteners:
   1. For anchoring or fastening applications in masonry and hollow-core precast concrete structural elements, provide masonry anchors as specified herein.
   2. For anchoring or fastening applications in cast-in-place concrete and solid precast concrete structural elements, provide concrete anchors as specified herein.
   3. Threaded Bolts:
      a. Draw threaded bolted connections up tight using 316 stainless steel lock washers to prevent the bolt or nut from loosening.
   4. Drilled-In Expansion Anchors:
      a. Install expansion anchors in strict accordance with manufacturer's instructions and the following.
         1) Drill holes to the required diameter and depth in accordance with anchor manufacturer's instructions for the size of anchor being installed.
         2) Minimum Embedment:
            a) Embed expansion anchors to four and one-half bolt diameters minimum unless otherwise indicated on the Contract Drawings.

C. Installation of U-Channel Support Framing Systems in accordance with Table 26 05 28-1 below:

Table 26 05 28-1 U-Channel Support Framing Selection

Condition 1	Condition 2	Type
Aboveground	Indoor – All locations	Carbon Steel

D. Installing Conduit Supports:
   1. For exterior locations provide malleable iron conduit supports.

E. In the wash bay, secure equipment and conduit to no fewer than two 7/8-inch minimum depth, non-metallic channels mounted vertically on the walls.

F. Field Fabrication:
   1. Fabricated Items:
      a. Fabricate backboards, backboard supports, equipment supports, conduit supports, and the other items as detailed on the Contract Drawings.
         1) Hot-dip galvanize mild-steel fabrications in accordance with the requirements of ASTM A 153/A 153M.
      b. Fabricate backboard posts as detailed on the Contract Drawings from concrete filled steel pipe with a crowned cap; and apply a prime paint finish.
      c. Supply components required for the anchorage of fabrications.

1) Except where specifically noted otherwise, fabricate anchors and related components from the same material as the fabrication and apply the same finish.

2. Tightly fit and secure joints.
   a. Make exposed joints butt tight, flush, and hairline.
   b. Weld fabricated assemblies in accordance with AWS D1.1/D1.1M.
      1) Continuously seal joined members using intermittent welds and plastic filler.
      2) Dress welds smooth and free of sharp edges and corners.
   c. Grind exposed joints flush and smooth with the adjacent finish surface.
3. Ease exposed edges to a small uniform radius.
   a. Cut all backboard corners to a 1-inch radius.
4. For the attachment of work and for bolted connections, accurately drill or punch holes for the fasteners as required.
   a. Burned holes are unacceptable.
   b. Provide holes no more than 3/32-inch larger than the fasteners.
5. Exposed Mechanical Fastenings:
   a. Except where specifically noted otherwise in the Contract Documents, provide flush countersunk screws or bolts; unobtrusively located, and consistent with the design of the component.
6. Fabrication Tolerances:
   a. Squareness: 1/8 inch (3 mm), maximum difference in diagonal measurements.
   b. Maximum offset between faces: 1/16 inch (1.5 mm).
   c. Maximum misalignment of adjacent members: 1/16 inch (1.5 mm).
   d. Maximum bow: 1/8 inch (3 mm) in 48 inches (1.2 m).
   e. Maximum deviation from plane: 1/16 inch (1.5 mm) in 48 inches (1.2 m).

3.04 REPAIR/RESTORATION

A. Coatings:
   1. Repair damage to coatings.
      a. Touch up damaged coating surfaces using the specified primer for primed steel surfaces, and using zinc-rich primer for galvanized steel surfaces.

3.05 FIELD QUALITY CONTROL

A. Inspection:
   1. Verify the adequacy of coatings.
   2. Inspect the items provided under this Section for adherence to the fabrication tolerances specified above, and correct any discrepancies:

3.06 PROTECTION

A. Protect the items provided under this Section from damage during the work of other trades.

END OF SECTION

SECTION 26 05 33.13

CONDUIT FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
1. Requirements for furnishing, installing, energizing, and testing conduit, tubing, and fittings for communication lines and electrical transmission, distribution, and service lines.

B. Related Section:
1. Division 01 Sections, as Applicable
2. Section 26 05 00 – Common Work Results for Electrical.
3. Section26 05 26 – Grounding and Bonding for Electrical Systems.
4. Section 26 05 28 – Hangers and Supports for Electrical Systems.
5. Section26 05 63 – Acceptance Testing of Electrical Systems.

1.02 REFERENCES

A. American National Standards Institute (ANSI):
1. ANSI/ASME B1.20.1 - Pipe Threads, General Purpose (Inch).
2. ANSI C80.1 - Rigid Steel Conduit - Zinc-Coated (GCR).

B. American Society for Testing and Materials (ASTM):
1. ASTM A 568/A 568M - Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold Rolled, General Requirements for.
2. ASTM D 1784 - Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

C. National Electric Manufacturer's Association (NEMA):
1. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit.

D. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electrical Code (NEC).

E. Underwriters Laboratory, Inc. (UL):
1. ANSI/UL 6 - Standard for Rigid Metal Conduit.
2. UL 94 - Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
3. ANSI/UL 360 - Standard for Liquid-Tight Flexible Steel Conduit.
4. ANSI/UL 498 - Standard for Safety for Attachment Plugs and Receptacles.
5. ANSI/UL 514A - Metallic Outlet Boxes.
6. ANSI/UL 1242 - Standard for Electrical Intermediate Conduit – Steel

1.03 DEFINITIONS

A. Definitions for all items are as stated in NFPA 70, IEEE C2, and in other reference documents unless otherwise stated, specified, or noted.

1.04 DESIGN REQUIREMENTS

A. Conduit Systems:
   1. Provide conduit of the type and material shown in Table 26 05 33.13-1 and 26 05 33.13-2 for the application indicated, or as indicated on the Contract Drawings.
   2. Provide conduit fittings made of material identical to that of the conduit system with which they are used.

Table 26 05 33.13-1 Conduit System Selection

Location	Condition 1	Condition 2	Conduit Type	Size (Minimum) [1]
Under-Ground	Encased	Bends, over 10 degrees in length	Rigid Galvanized Steel	1 Inch
		Conduit Risers	Rigid Galvanized Steel	1 Inch
		Straight Runs	PVC Schedule 40	1 Inch

1 No conduit smaller than 1-inch trade size is permitted unless indicated otherwise on the Contract Drawings.

Table 26 05 33.13-2 Conduit System Selection

Location	Condition 1	Condition 2	Conduit Type	Size (Minimum) [1]
Above-Ground	Outside	Exposed to weather	Rigid Galvanized Steel	3/4 Inch
	Inside – 12’ from centerline of wash bay drive lane	Within 36-inches of floor when exposed	PVC Schedule 80	3/4 Inch
	Inside	Other Locations	Rigid Galvanized Steel	3/4 Inch
	Inside	Flexible Connections	LFMC	3/4 Inch

1 No conduit smaller than 3/4-inch trade size is permitted unless indicated otherwise on the Contract Drawings.

1.05 SUBMITTALS

A. Submit the following information to the Engineer for approval in accordance with the requirements of Section 01 33 00, Submittal Procedures:
   1. Product Data:
      a. Rigid Polyvinyl Chloride (PVC) Conduit.
      b. Non-metallic conduit solvent.
      c. Liquidtite flexible metal conduit.
      d. Rigid galvanized steel conduit (RGS).
      e. Fittings for non-metallic conduit systems.
      f. Fittings for metallic conduit systems.
      g. Conduit spacers.
      h. Heat shrink tubing.
      i. Wall and floor penetration seals.
      j. Cold galvanize coating.
   2. Shop Drawings:
      a. Proposed departures from the original design.
   3. Quality Assurance/Control Submittals:
      a. Qualification Statements:
         1) Qualifications of the installer.
         2) Qualifications of the Electrical Testing Laboratory (ETL).
      b. Certificates:
         1) Testing agency/quality verification, listing, and labeling.

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Installer Qualifications:
      a. Employ an installation firm with a minimum of three years documented experience installing conduit and tubing similar in type and scope to that required by this Contract to install the Work of this Section.
      b. Employ skilled licensed electricians to supervise the Work of this Section.
      c. Submit information verifying the installer's qualifications.
   2. Electrical Testing Laboratory (ETL) Qualifications:
      a. Employ an independent testing agency, qualified as specified in Division 01 and Section 26 05 00 Common Work Results for Electrical, to perform the testing required by this Section.
      b. Submit information verifying the ETL's qualifications.

B. Regulatory Requirements:
   1. Perform the Work of this Section in accordance with the requirements specified in NFPA 70 (NEC), and to other applicable state, local, and national governing codes and regulatory requirements.
   2. All items installed from utility service poles to the main service panels must be approved by the serving utility, whether electrical service or telephone service, as listed in Section 26 05 00 Common Work Results for Electrical.

C. Certifications:
1. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory (ETL) for the location the product is installed in, and the application intended, unless products meeting the requirements of these nationally recognized testing laboratories are not available or unless standards do not exist for the products.
    a. Submit evidence with the Product Data that the products represented meet testing agency quality verification requirements, including agency listing and labeling requirements.
        1) Such evidence may consist of either a printed mark on the data or a separate listing card.
    b. Submit a written statement from those product manufacturers that do not provide evidence of the quality of their products that indicates why an item does not have a quality assurance verification.
        1) Such statements provided in lieu of quality assurance verification are subject to the acceptance of the Owner and the Engineer.

1.07 DELIVERY, STORAGE AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
1. Pack, ship, handle, and unload products in accordance with the requirements of Section 26 05 00 Common Work Results for Electrical, and as detailed herein.

B. Acceptance at Site:
1. Acceptance products at the Site in accordance with the requirements of Section 26 05 00 Common Work Results for Electrical, and as detailed herein.

C. Storage and Protection:
1. Store products in accordance with the requirements of Section 26 05 00 Common Work Results for Electrical, and as detailed herein.
    a. Store all products indoors on blocking or pallets.

PART 2 PRODUCTS

2.01 NON-METALLIC CONDUIT

A. Electrical Plastic Tubing and Conduit:
1. Rigid Polyvinyl Chloride (PVC) Conduit:
    a. Provide high impact PVC conduit conforming to the requirements of NEMA TC 2 at 90 degrees Celsius, and made from compounds conforming to the requirements of ASTM D 1784.
        1) Use material that at 78 degrees Fahrenheit has a tensile strength exceeding 5500 psi, a flexural strength exceeding 11,000 psi, and a compressive strength exceeding 800 psi,

b. Provide PVC conduits that are UL listed, labeled, or approved for both underground and above ground use.

2. Manufacturers:
   a. JM Eagle,
   b. Queen City Plastics, Inc.,
   c. Prime Conduit Inc.,
   d. Tyco/Allied Tube and Conduit
   e. Approved equal.

B. Non-Metallic Conduit Solvent:
1. Provide solvent for non-metallic conduit joints from the same manufacturer as the conduit and conforming to the requirements of ASTM D 2564.

2.02 METALLIC CONDUIT

A. Liquidtite Flexible Metal Conduit:
1. Provide PVC coated flexible metal conduit conforming to the requirements of Article 350 of NFPA 70 (NEC) for materials and uses and ANSI/UL 360.
2. Provide conduit with interlocking spiral strip construction capable of bending to a minimum radius of five times its diameter without deforming the spiral strips both inside and outside of the conduit.
   a. Provide conduit with a flexible, galvanized, interlocking spiral strip steel core jacketed with smooth, liquid-tight polyvinyl chloride designed to withstand temperatures from minus 40 degrees Celsius to plus 60 degrees Celsius.
3. Finish the interior and exterior of flexible conduit smooth and free from burrs, sharp edges, and other defects that may injure wires; and place the manufacturer's trademark on each length.
4. Furnish an integral continuous copper ground in 1/2-inch through 1-1/4-inch PVC coated flexible metal conduit.
5. Acceptable Manufacturers
   a. Electri-Flex Company, Liquatite®, Type LA
   b. ANAMET Electrical, Inc., Anaconda Sealtite®
   c. Approved equal.

B. Rigid Galvanized Steel Conduit (RGS):
1. Provide rigid galvanized steel conduit (RGS) conforming to the requirements of Article 344 of NFPA 70 (NEC) for materials and uses, ANSI C80.1, and UL 6.
2. Fabricate the RGS from mild steel piping, galvanized or sherardized inside and outside, and protected against corrosion by a dichromate rinse or a zinc chromate coating.
3. Provide defect free conduit bearing the UL label, and furnished in 10-foot minimum lengths with both ends threaded and one end fitted with a coupling.
   a. Provide tapered NTP 3/4 inch per foot threads complying with ANSI/ASME B1.20.1.
4. Acceptable Manufacturers:
   a. Tyco/Allied Tube and Conduit

b. Wheatland Tube Company, Division of John Maneely Company
c. Approved equal.

2.03 CONDUIT FITTINGS

A. Fittings for Non-Metallic Conduit Systems:
1. Electrical Plastic Tubing and Conduit:
a. Provide high impact non-metallic fittings conforming to same requirements as for the plastic tubing and conduit as specified in Article 2.01.
b. Non-Metallic Conduit Expansion Fittings:
1) Provide a two-piece nonmetallic, noncorrosive, nonconductive, UL listed expansion fitting.
c. Acceptable Manufacturers:
1) Lamson & Sessions, Carlon®
2) Queen City Plastics, Inc.
3) Approved equal.

B. Fittings for Threaded Metallic Conduit Systems:
1. Construct conduit bodies/fittings from cast malleable iron or cast steel.
2. Conduit Outlet Bodies:
a. Provide malleable iron threaded entry type conduit outlet bodies with neoprene gaskets and cast steel cover.
b. Acceptable Manufacturers:
1) EGS/Appleton Electric
2) EGS/O-Z/Gedney
3) Approved equal.
3. Conduit Expansion Joints:
a. Provide telescoping sleeve type galvanized, weatherproof, and vapor tight conduit expansion joints designed for 4-inch maximum expansion with an insulated bushing and lead-wool packing.
b. Acceptable Manufacturers:
1) EGS/Appleton Electric
2) EGS/O-Z/Gedney
3) Approved equal.
4. Conduit Unions:
a. Provide conduit unions capable of completing a conduit run when neither conduit end can be turned.
b. Acceptable Manufacturers:
1) EGS/Appleton Electric, UNF and UNY Unions
2) Thomas and Betts Company, Erickson® Coupling.
3) Approved equal.
5. Conduit Outlet Boxes:
a. Provide malleable or cast iron conduit outlet boxes conforming to the requirements of UL 886, and having a cover with O-rings to keep out moisture.

b. Acceptable Manufacturers:
   1) EGS/Appleton Electric, GRF outlets and covers
   2) EGS/O-Z Gedney
   3) Approved equal.

6. Conduit Device Boxes:
   a. Provide malleable iron conduit device boxes with internal grounding screws and conforming to the requirements of UL 498 and UL 514A.
   b. Acceptable Manufacturers:
      1) EGS/Appleton Electric, FD device boxes
      2) EGS/O-Z Gedney
      3) Approved equal.

2.04 CONDUIT SPACERS

A. Provide non-metallic, interlocking type conduit spacers which snap together to join any combination of intermediate and base units together, both vertically and horizontally.

B. Manufacturers:
   1. Underground Devices Inc.
   2. The George-Ingraham Corp.
   3. Approved equal.

2.05 HEAT SHRINK TUBING

A. Provide all-weather corrosion resistant vinyl plastic heat shrink tubing designed for application on the exterior of metallic conduit to protect against galvanic action, moisture or other deteriorating contaminants.

B. Manufacturers:
   1. Tyco Electronics, Raychem
   2. Thomas & Betts
   3. Approved equal.

2.06 WALL AND FLOOR PENETRATION SEALS

A. Provide watertight mechanical seals capable of holding up to 20 psig, and sealing against water, soil, and backfill material.

B. Acceptable Manufacturers:
   1. Pipeline Seal & Insulator, Inc., Thunderline/Link-Seal
   2. Flexicraft Industries, PipeSeal
   3. Approved equal.

2.07 FINISHES

A. Cold Galvanize Coating:

1. Provide a cold galvanize coating to provide protection against corrosion by forming an insoluble zinc salt barrier from a cathodic reaction when the coating is damaged by abrasion and exposed to weather.
    a. Provide a single component pre-mixed liquid organic zinc compound producing 95 percent zinc in the dry film.
    b. Provide a coating that bonds to clean iron, steel, or aluminum through electrochemical action.
2. Acceptable Manufacturers:
    a. ZRC. Worldwide
    b. Clearco
    c. Krylon
    d. Rustoleum
    e. Or Approved Equal

PART 3 EXECUTION

3.01 EXAMINATION

A. Although the Contract Drawings are generally indicative of the Work, take field measurements to verify actual conditions.
    1. Due to the small scale of the Contract Drawings it is not possible to indicate all offsets, fittings, and apparatus required or the minor structural obstructions that may be encountered during the Work.

B. Inspect the condition of existing conduit that is required for the Work of this Section.

3.02 PREPARATION

A. After carefully investigating structural and finish conditions and other in-place construction work, prepare and submit detailed Shop Drawings showing proposed departures from the original design due to field conditions or other causes.
    1. Layout the electrical work according to accepted standard electrical trade practice to suit actual field measurements.
    2. Arrange the electrical work to consider existing conditions and to preserve access to other equipment, rooms, areas, and similar features of the construction.
    3. Include plan and profile views of duct banks.
    4. Indicate the location and details of conflicting utility construction and slopes.
    5. Submit these Shop Drawings to the Engineer for approval prior to performing the Work of this Section.

B. Submit Product Data and catalog cuts for all products provided under this Section.
    1. Clearly indicate the usage of each product on the submittal.

C. Obtain roughing-in dimensions of electrically operated equipment, including equipment being installed by both electrical and other construction trades.

1. Set conduit and boxes only after receiving approved dimensions and checking such equipment locations.

D. Remove dirt, debris, and other obstructions from existing conduit required for the Work of this Section by blowing out and mandreling the conduits as applicable.

3.03 INSTALLATION

A. Perform the Work of this Section as specified in Section 26 05 00, Common Work Results for Electrical.

B. Fabricate and install conduit and wireway systems in accordance with accepted electrical trade standard practice.
1. Layout the electrical work of this Section to suit actual field measurements.
    a. Record the actual installed elevations and locations of duct banks and the as-found locations of conflicting utility lines on the record drawings specified in Section 01780, Closeout Submittals, and submit the record drawings.
2. Install the electrical Work of this Section in conformance to the wiring methods general requirements of Article 300 in NFPA 70 (NEC), and to all other applicable Articles of NFPA 70 governing wiring methods.
3. Cut conduit and wireway square, and ream the cut ends according to the requirements of NFPA 70 (NEC) to deburr the openings so that they are not restricted more than cuts made by the material manufacturer.
4. Avoid bending conduits as much as possible and practical; but if bends are made, use an approved conduit bending tool or machine to make the bends.
5. Do not install crushed or deformed conduit, and remove crushed or deformed conduit from the Site.
6. On conduit that is installed outside, provide a second equipment ground conductor and use fittings with a built-in ground lug for bonding.
7. Provide flexible conduit only to the extent permitted by NFPA 70 (NEC).
    a. In flexible conduits that do not have an integral ground wire, install a green insulated wire in addition to the neutral wire for grounding purposes.
        1) Form a ‘J’ or ‘S’ hook with a drip loop to allow flexibility.
        2) Provide a second equipment grounding conductor on outside conduit and provide fittings with built-in ground lug for bonding.
    b. In exposed areas, use PVC coated flexible metal conduit and fittings.
    c. Use flexible metal conduit or liquid tight flexible metal conduit for final connection to recessed lighting fixtures and rotating and vibrating equipment.
        1) Flexible Metal Conduit is only permitted for final connections to lighting fixtures in dry, environmentally conditioned spaces.
        2) Liquid tight flexible metal conduit, as herein specified, for final connection to recess mounted lighting fixtures in unconditioned spaces and to all rotating and vibrating equipment including transformers, motors, solenoid valves, pressure switches, limit switches, generators, engine-mounted devices and pipe-mounted devices.

3) Flexible conduit not to exceed 18 inches in length for motor connections, 36 inches in length for equipment connections or 72-inches for lighting fixture connections.

8. Provide fittings and apparatus as required to construct the approved electrical design.
   a. Running threads on conduit are not permitted.
      1) Where couplings and connectors are required for metal conduits, use approved threaded couplings and connectors.
   b. Provide conduit unions where necessary to complete a conduit run when neither conduit end can be turned.
   c. Where conduit and raceway runs cross building expansion joints, make provision for expansion in the conduit and raceway runs.
   d. Provide sealing fittings with drain fittings in all lower runs and vertical runs.
   e. Provide sealing covers for junction boxes where required.
   f. Provide weatherproof conduit hubs on all conduit connections exterior to the building, and on instruments, process equipment, and pump motors.
9. Installing RGS and PVC Coated Conduit:
   a. Installation of the RGS and PVC Coated Conduit System shall be performed in accordance with the Manufacturer's recommendations.
   b. To assure correct installation of PVC Coated Conduit System, the installer shall have a current and unexpired certification provided by the Manufacturer to install coated conduit.
   c. Threading Conduit:
      1) Field thread the conduits per the manufacturers instructions.
         a) For PVC coated conduit, first use a cylindrical guide, oversized to fit over the plastic coating, to neatly cut the coating off at the proposed end of the threads.
         b) Do not damage or remove the coating beyond the proposed end of the threads.
      2) Once the threading operation is complete, protect the newly cut threads against corrosion by applying a "sealing" compound as recommended by the manufacturer.
   d. Assembling RGS and PVC Coated Conduit Fittings:
      1) Use PVC coated conduit bodies, clamps, supports, accessories, and fittings with coated conduit systems.
      2) Just prior to assembling each conduit joint, apply the conduit manufacturer's touch-up compound to the end of the conduit in the area normally covered by the fitting sleeve.
      3) Use cloth or other material over strap type wrenches to protect the coating while tightening conduits.
10. Breathers and drains shall be provided at the low point(s) of all conduit runs in NEMA 3R, 4, and 4X areas, and where otherwise subject to the accumulation of condensation. Conduits shall be arranged to drain away from dry areas toward damp or wet areas, and away from equipment and enclosures.

C. Exposed Work:
1. In exposed work, run conduit and raceway parallel to centerlines and structure surfaces; or perpendicular to centerlines where required, with right angle turns consisting of symmetrical bends or fittings.
2. Maintain at least 6 inches clearance between conduit and raceway runs and pipes, ducts, and flues of mechanical systems.
3. If a portion of a metallic conduit run, whether plastic-coated or not, extends above grade or is otherwise exposed to personnel, ensure that the conduit is properly bonded to an equipment grounding conductor at both ends.
    a. Install the equipment grounding conductor either inside or outside the box.

D. Concealed Work:
1. When performing electrical work in concealed spaces, provide the same quality workmanship as in exposed work.
2. Conceal conduits and raceways in the structure's construction where practicable unless otherwise indicated on the Contract Drawings or required by the Engineer.
    a. Group conduit and raceway runs in concealed work as much as practical to avoid congesting the concealed spaces.
    b. Do not weaken the structure by excessive or unnecessary cutting.
        1) Only make cuts into the structure's construction in conformance to the applicable building codes.
3. Conduits and Raceways Embedded in Concrete Slabs:
    a. Separate multiple conduits encased together by not less than two inches of concrete.
    b. Locate conduit installed in floor slabs within the reinforced area of the slab.
    c. Where conduit crosses expansion joints, provide weather tight expansion and defection fittings and bonding jumpers.

E. Hangers and Supports:
1. Install auxiliary support structures, anchors, and fasteners as specified in Section 26 05 28, Hangers and Supports for Electrical Systems.
    a. Mount or suspend conduit and wireway systems directly on structural members of the structures and walls.
    b. Do not attach conduit or raceway systems to suspended ceiling members or to the suspending mediums.
    c. Securely attach anchors into walls.
2. At all conduit attachments, allow space between the mounting surfaces and the conduit by providing U-channel supports, clamp-backs, or spacers.
    a. Attach wall-mounted conduit runs close to the walls following the contour of the walls, parallel to the walls and other building lines except at bends.

F. Structure Penetrations:
1. Make penetrations in existing concrete structures by core-drilling.
    a. Drill the penetrations true, clean, and free from spalling.

2. At penetrations through fire rated floors, walls, and similar assemblies, provide firestopping as specified in Section 07 84 00, Firestopping.
3. Make floor penetrations as detailed on the Contract Drawings.
    a. Seal all conduit penetrations through floor slabs on grade in buildings with a floor penetration seal.
4. Install a wall penetration seal at all wall penetrations.
    a. Size wall penetrations to accommodate the conduit outside diameter plus either 1/4 inch or a hole allowance to allow the installation of the wall penetration seal.
5. For conduits that enter rooms from concrete floors or masonry, provide corrosion protection by using an RGS or PVC coated conduit that extends from 12 inches inside the concrete or masonry to at least 6 inches into the room.

G. Wiring:
1. Install wiring in conduit as indicated.
2. Prior to the installation of any wire, verify that the conduit is clean and free of debris.
3. Install a separate ground conductor within every conduit.

3.04 FIELD QUALITY CONTROL

A. Inspection:
1. Inspect installed conduit runs for obstructions, proper support, proper grounding, and completeness.
2. Record the actual installed elevations and locations of conduit and tubing on record drawings specified in Division 01.

END OF SECTION

SECTION 26 05 33.23

BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
1. Requirements for furnishing, installing, connecting, cleaning, and protecting electrical pull and junction boxes.

B. Related Section:
1. Division 01 Section, as Applicable
2. Section 26 05 00 – Common Work Results for Electrical.
3. Section 26 05 26 - Grounding and Bonding Electrical Systems.
4. Section 26 05 28 - Hangers and Supports for Electrical Systems.
5. Section 26 05 63 – Acceptance Testing of Electrical Systems.
6. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
7. Section 26 05 33.13 – Conduits for Electrical Systems.

1.02 REFERENCES

A. National Electric Manufacturer's Association (NEMA):
1. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
2. ANSI/NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable.
3. NEMA RN 1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.

B. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electrical Code (NEC).

C. American National Standards Institute (ANSI):
1. ANSI Z55.1 - Gray Finishes for Industrial Apparatus & Equipment (*withdrawn 1990, no replacement*).

1.03 DESIGN REQUIREMENTS

A. Product Data:
1. Submit a list of the materials proposed to satisfy the requirements of this Section.
2. Submit the manufacturer's comprehensive calculations used to determine size requirements for the boxes.
3. Submit Product Data and catalog cuts of the materials and equipment proposed to be used to satisfy the requirements of this Section.

1.04 SUBMITTALS

A. Submit the following information to the Engineer for approval in accordance with the requirements of Division 01:
   1. Product Data:
      a. List of the proposed materials.
      b. Catalog cuts of cast outlet boxes for general purpose applications used with steel conduit systems.
      c. Catalog cuts of sheet metal boxes for general purpose applications in dry locations.
      d. Catalog cuts of equipment and control device enclosures.
   2. Quality Assurance/Control Submittals:
      a. Design Data.
         1) Manufacturer's comprehensive calculations.
      b. Test Reports.
         1) Factory test reports.
      c. Certificates.
         1) Testing agency/quality verification, listing, and labeling.
      d. Qualification Statements.
         1) Qualifications of the licensed electricians.
         2) Qualifications of the Electrical Testing Laboratory (ETL).

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Installer Qualifications:
      a. To supervise installation of the Work of this Section, employ licensed electricians.
         1) Submit the qualifications of the licensed electricians supervising the Work of this Section.
   2. Electrical Testing Laboratory (ETL) Qualifications:
      a. Employ an independent testing agency, qualified as specified in Division 01 and Section 26 05 63, Electrical Testing, to perform testing required by this Section.
      b. Submit information verifying the ETL’s qualifications.

B. Regulatory Requirements:
   1. Perform the Work of this Section in accordance with the requirements specified in Articles 250, 300, and 370 of NFPA 70 (NEC), and to all other applicable state, local, and national governing codes and regulatory requirements.

C. Certifications:
   1. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory (ETL) for the location installed in, and listed and labeled or approved for the application intended as indicated or specified, unless products

meeting the requirements of these testing laboratories are not readily available or unless standards do not exist for the products.
   a. Provide products that are approved, listed, and labeled for the short circuit currents, voltages, and currents indicated or specified to be applied.
   b. Provide service entrance labeled products for all service entrance equipment.
2. Submit evidence of testing agency/quality verification, listing, and labeling for each product with the submitted product data, either by providing a printed mark on the data or by attaching a separate listing card.
   a. For items without such evidence, submit a written statement from the product manufacturer that indicates why it does not have quality assurance verification.

1.06 MATERIAL DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
   1. Pack, ship, handle, and unload products in accordance with the requirements of Section 26 05 00, Common Work Results for Electrical.

B. Acceptance at Site:
   1. Accept products at the Site in accordance with the requirements of Section 26 05 00, Common Work Results for Electrical.

C. Storage and Protection:
   1. Store products in accordance with the requirements of Section 26 05 00, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Use of Trade Names:
   1. The use of trade names within the Contract Documents is intended to establish the basis of design and to illustrate the constructability and level of quality required.
   2. The use of trade names is not intended to exclude other manufacturers whose products are equivalent to those named, subject to compliance with Contract requirements.

2.02 MANUFACTURED UNITS

A. Cast Outlet Boxes for General Purpose Applications:
   1. For Use with Steel Conduit Systems:
      a. For use with steel conduit systems, provide UL Listed small cast steel or cast malleable iron outlet boxes with threaded hubs that meet the NEMA 250 requirements for Type 12 enclosures.
      b. If covers are indicated or specified, provide cast steel or cast malleable iron covers with neoprene gaskets.

1) Provide captive Type 316 stainless steel mounting screws for the covers.

c. If fixture hangers are indicated or specified, provide ball type cast steel or cast malleable iron fixture hangers with neoprene gaskets.
   1) Provide captive Type 316 stainless steel mounting screws for the fixture hangers.

d. Finish:
   1) Provide outlet boxes, covers, and hangers with an electroplated zinc coating, followed first by a dichromatic prime, and then by an aluminum polymer finish coating conforming to NEMA FB 1.

e. Manufacturers:
   1) Appleton Electric
   2) O-Z/Gedney
   3) Crouse Hinds
   4) Thomas & Betts
   5) Killark
   6) Or Approved equal.

B. Sheet Metal Junction and Pull Boxes for General Purpose Applications:
   1. For general purpose applications in dry locations, provide small sheet steel pull and terminal boxes and covers that meet the NEMA 250 requirements for Type 12 enclosures with continuously welded and ground smooth seams, and having no holes or knockouts.
      a. Cover:
         1) Provide overlapping sheet steel screw covers with captivated screws for each box.
         2) Provide a means of bonding on the cover.
      b. Gasket: Provide an oil resistant cover gasket for each box.
      c. Mounting Brackets:
         1) Provide 12 gauge steel wall-mounting brackets.
      d. Finish:
         1) Provide polyester powder coating applied over phosphatized surfaces.
         2) Color: ANSI Z55.1 Number 61 gray.
   2. Manufacturers:
      a. Pentair, Screw Cover SC Junction Boxes
      b. Rittal Corp
      c. Milbank Manufacturing
      d. Or Approved Equal

C. Equipment and Control Device Enclosures:
   1. For all areas except outdoor and corrosive locations, provide enclosures with hinged doors that meet the NEMA 250 requirements for Type 4 or 12 enclosures, depending on Contract requirements.
      a. Enclosure Cabinet:
         1) Provide sheet steel boxes having continuously welded seams, ground smooth.

2) Provide enclosures having no holes or knockouts.
b. Enclosure Door:
1) Provide overlapping sheet steel hinged doors, having a continuous hinge with a removable heavy gauge hinge pin and door clamps with screws to provide a watertight seal or to exclude liquids and contaminants.
2) Provide a means of bonding on the door.
c. Door Gasket:
1) Provide an oil resistant door gasket for each box.
d. Security:
1) Provide a mechanism for padlocking the enclosure.
e. Finish:
1) Provide polyester powder coating applied over phosphatized surfaces.
2) Color: ANSI Z55.1 Number 61 gray.
f. Manufacturers:
1) Pentair, Single-Door Type 4 Enclosures or Type 12 and Type 13 Enclosures
2) Rittal Corp
3) Milbank Manufacturing
4) Or Approved Equal

2. For outdoor locations, provide galvanized steel enclosures with covers that meet the NEMA 250 requirements for Type 3R enclosures, and as follows.
a. Enclosure Body:
1) Fabricate enclosures from galvanized steel sheets; and provide a drip shield on the top, and seam-free sides, fronts, and backs.
b. Covers:
1) Provide a removable slip-on cover with plated steel captivated screws along the bottom edge for each enclosure.
c. Security:
1) Provide a mechanism for padlocking the enclosure.
d. Finish:
1) Provide polyester powder coating applied over phosphatized surfaces.
2) Color: ANSI Z55.1 Number 61 gray.
e. Manufacturers:
1) Pentair, Screw Cover Type 3R Enclosures
2) Rittal Corp
3) Milbank Manufacturing
4) Or Approved Equal

2.03 SOURCE QUALITY CONTROL

A. Tests:
1. Submit factory test reports to the Engineer as specified for the products in this Section.

PART 3 EXECUTION

3.01 INSTALLERS

A. Install the work of this Section only under the supervision of licensed electricians.

3.02 EXAMINATION

A. Verify that conduit stub-ups to be mated with electrical boxes and enclosures are the correct type and size, and are at the proper location.

3.03 INSTALLATION

A. Junction Boxes and Pull Boxes for General Purpose Applications:
   1. For general purpose applications in dry locations, provide small sheet steel pull and terminal boxes that meet the NEMA 250 requirements for Type 12.
   2. Provide boxes that are fabricated from the same type of material as the conduit with which the boxes are used.

B. Equipment and Control Device Enclosures:
   1. For all areas except outdoor locations, provide enclosures that meet the NEMA 250 requirements for Type 4 or 12 enclosures, depending on Contract requirements.
   2. For outdoor locations, provide enclosures with covers that meet the NEMA 250 requirements for Type 3R enclosures.

C. Installing Boxes for Electrical Outlets and Devices:
   1. Install boxes level and plumb within 1/16-inch of vertical or horizontal over the length of the box.
   2. Unless otherwise indicated on the drawings, devices boxes for interior or exterior wiring devices of buildings shall be recessed within the wall construction. The installation of surface mounted device boxes is prohibited.
   3. Install device boxes at a uniform height as indicated on the Contract Drawings.
      a. Mount all adjacent boxes in alignment at the same mounting height.
      b. Mount outlet boxes for equipment within 18-inches of the equipment power connection.
   4. When installing boxes outside or to exposed conduit, provide cast boxes.
      a. For interior unfinished locations mount these boxes on spacers to be 1/8-inch from wall unless box has built-in raised pads to perform the same function.
   5. When installing boxes for single devices, two devices, or wall outlets, install 4-inch square boxes with appropriate plaster rings.
      a. Space boxes on opposite sides of the wall 6 inches apart.
      b. Set plaster rings flush or to protrude less than 1/16-inch from the wall.
      c. Openings for boxes in finished walls must be within 1/16-inch of the box.
         1) Correct all oversize openings in accordance with the specifications for the wall material.

6. Outlet boxes must be of the one-piece type, the use of expandable sheet metal boxes is prohibited.
7. Support cast boxes for outlet and device using one of the following methods:
    a. Mount the boxes directly to the structure using 4 or more anchors.
        1) Attach mounting screws to feet located outside of the box interior.
        2) Provide 1/4-inch spacers behind the boxes unless the box has raised pads.
    b. Attach the box to two 1-inch or larger conduits which are supported within 12-inches of the box.
    c. Attach the box to two 1-inch or larger conduits which exit from a poured concrete floor no further than 18-inches from the box.

D. Installing Boxes for Other than Electrical Outlets and Devices:
1. Accurately punch holes for conduit openings using a hydraulic punch and punches sized for the conduit to be installed.
2. Install a conduit breather in the top of the box and a conduit drain fitting in the bottom of all boxes not located in bone-dry areas that are at least 100 feet from a hose-bib.
3. Support boxes for other than electrical outlets and devices using one of the following methods:
    a. Mount the boxes directly to the structure using 4 or more anchors.
        1) Attach mounting screws to feet located outside of the box interior. or seal the screw holes to prevent water penetration.
        2) Provide 1/4-inch spacers behind the boxes unless the box has raised pads.
    b. Attach the box to two 1-inch or larger conduits which are supported within 12-inches of the box.
    c. Attach the box to two 1-inch or larger conduits which exit from a poured concrete floor no further than 18-inches from the box.
    d. Mount the box on U-channel and structural supports conforming to Section 26 05 28, Hangers and Supports.

E. Make up all conduit connections to boxes in accordance with the requirements of Section 26 05 33.13, Conduit and Tubing.

F. Install wiring in boxes in accordance with the requirements of Section 26 05 19, Low-Voltage Wire, Cable, and Accessories.

G. Ground boxes in conformance with Section 26 05 26, Grounding and Bonding.

3.04 REPAIR/RESTORATION

A. Touch up damaged coatings on electrical boxes and enclosures.

3.05 FIELD QUALITY CONTROL

A. Site Tests:
   1. Test all boxes to verify that they are properly connected to the grounding system.

B. Inspection:
   1. Inspect flush boxes to verify that the opening between the box and the wall finish is less than 1/16-inch.
   2. Inspect flush boxes to verify that each box is flush with the wall, or protrudes less than 1/16-inch, and is not set behind the wall surface.
   3. Inspect surface mounted boxes to verify that they are level and plumb within 1/16-inch as specified.
   4. Record the actual installed elevations and locations of pull and junction boxes on record drawings specified in Division 01.

3.06 CLEANING

A. Waste Management and Disposal:
   1. Clear and dispose of waste materials in accordance with the requirements of Section 26 05 00, Common Work Results for Electrical.

3.07 PROTECTION

A. Except for surfaces to be painted, mask electrical boxes to protect them from paint overspray or over-brushing during painting operations.

B. Protect boxes against damage from other work.

END OF SECTION

SECTION 26 05 53

ELECTRICAL IDENTIFICATION

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Requirements for furnishing, installing, and protecting identification signs and labels for electrical systems.

B. Related Section:
   1. Section 26 05 00 – Common Work Results for Electrical
   2. Section 26 05 19 - Low-Voltage Wire, Cable, and Accessories
   3. Section 26 28 16 .13 - Low-Voltage Enclosed Switches
   4. Section 26 24 16 - Panelboards
   5. Section 26 22 00 - Low-Voltage Transformers

1.02 REFERENCES

A. American National Standards Institute (ANSI):
   1. ANSI Z535.4, Product Safety Signs and Labels.

B. National Electrical Manufacturer's Association (NEMA):
   1. NEMA 250, Enclosures for Electrical Equipment.

C. National Fire Protection Association (NFPA):
   1. NFPA 70, National Electrical Code (NEC).
   2. NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces.
   3. NFPA 704, Identification of the Hazards of Materials for Emergency Response

D. International Code Council
   1. International Fire Code (IFC)

1.03 DEFINITIONS

A. Mimic bus refers to a graphical representation of the devices and bus work within an item of electric equipment.

1.04 SUBMITTALS

A. Submit the following information for approval in accordance with the requirements of Division 01 and Section 26 05 00:
   1. Product Data:

a. Provide catalog cuts for the actual products provided and indicate clearly the usage of each product.
2. Shop Drawings:
a. Provide a schedule depicting all nametag legends.
b. Provide drawings of typical nametags.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements:
1. Comply with the all applicable requirements of OSHA, but particularly those stated in 29 CFR 1910.144 and 29 CFR 1910.145.
2. Comply with the requirements of NFPA 70E that are applicable to electrical identification items as listed below in this Specification Section.

1.06 DELIVERY, STORAGE AND HANDLING

A. Protect items from damage during delivery, storage, and handling in accordance with Section 26 05 00 and as detailed below.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide products meeting the specified requirements from one of the following manufacturers, unless otherwise indicated:
1. Brady Worldwide, Inc., P. O. Box 2131, Milwaukee, WI 53201-2131, Telephone (414) 358-6600.
2. Seton Identification Products, 20 Thompson Road, P. O. Box 819, Branford, CT 06405-0819, Telephone (800) 243-6624..
3. LEM Products, Inc.; P. O. Box 190, 4089 Landisville Road, Doylestown, PA 18901, Telephone (800) 220-2400 or (215) 348-9900.

B. To serve as examples of the quality required of the specified products, several Brady Worldwide, Inc. Product Numbers are listed for informational purposes only.

2.02 MATERIALS

A. Laminated Phenolic or Plastic:
1. Provide rigid, thermosetting resin or polymer material that is heat- and fire-resistant, abrasion resistant, electronically non-conductive, and non-corroding.
2. Extrude the thermosetting resin or polymer into sheets, and laminate the sheets together so that colored top and bottom layers sandwich a contrasting color core in the middle.

B. Mounting Hardware:

1. Provide number 10 hex-head machine screws and lock-washers, or hex-head bolts, lock-washers, and nuts for mounting identification nameplates onto electrical equipment.
2. Provide either type 316 stainless steel or brass fasteners; however, all fasteners used on the same nameplate must be of the same material.

2.03 EQUIPMENT IDENTIFICATION NAMEPLATES

A. Provide laminated phenolic or plastic equipment identification nameplates having beveled edges and engraved lettering.
   1. Drill holes for mounting hardware in the equipment identification nameplates as follows:
      a. For nameplates that are more then 2 inches wide, drill four holes.
      b. For nameplates that are more than 1-1/2 inches high, drill four mounting holes.
      c. For smaller nameplates, drill holes for two fasteners.
   2. Provide equipment identification nameplates long enough to ensure that the heads of fastening hardware do not extend beyond the nameplate material, and come no closer than 1/16-inch to the nearest letter of the nameplate legend and no closer than 1/16-inch to the nearest edge.

B. Engrave the following information on each equipment identification nameplate, similar to that shown in Examples 1 and 2 below except appropriate for the specific equipment being identified:
   1. In the first line, indicate the equipment type and identification number.
   2. In the second line, indicate the equipment Voltage, the equipment current if known, the phase, and the number of wires.
      a. If the current is listed, provide a description that further identifies the current, such as “overload protection current”, full load amps (FLA), or other information identifying the current indicated.
   3. In the third line, indicate the words “SERVED FROM” followed by the serving equipment and the branch circuit.
      a. If multiple sources serve the equipment, list all sources on succeeding lines.

EXAMPLE 1:

POWER PANELBOARD PPB-2
208/120 VOLTS, 10.8 FLA, 3-PHASE, 4-WIRE
SERVED FROM
PPB-1, CIRCUITS F1 THROUGH T1

      b. If the equipment is supplied through automatic transfer switches and transformers or other items without disconnects, include data on all upstream

disconnects; and beneath the sources add the word "THROUGH" followed by the name of the equipment that the sources are connected through.

EXAMPLE 2:

POWER PANELBOARD PPB-2
480/277 VOLTS, 3-PHASE, 4-WIRE
SERVED FROM
BOTH EGS-2 AND MCC-1
THROUGH ATS-1

4. For motor starters, circuit breakers, transformers, and disconnect switches, provide an additional line with the word "SERVES" and the equipment served.

C. Engrave the following information on identification plate for any distribution equipment (i.e. switchboard, panelboard, motor control center, switchgear, etc).
   1. The conductor insulation color coding for feeder and branch circuit wiring originating from each piece of distribution equipment per NFPA 70. Refer to Specification Section 26 05 19 for wire and cable color coding requirements.

      EXAMPLE for 208Y/120 volt equipment:

PHASE	COLOR
A	BLACK
B	RED
C	BLUE
GROUNDED CONDUCTOR (NEUTRAL)	WHITE
EQUIPMENT GROUNDING CONDUCTOR	GREEN

D. Engrave equipment identification nameplates with all capital, Helvetica Medium font, or equal, lettering.
   1. Provide white letters on a black background, except for warning nameplates provide white lettering centered on red backgrounds.
   2. Provide a minimum 1/8-inch border between the nameplate lettering and the tops and bottoms of the nameplates.
   3. Use 3/8-inch high letters for the first line, and 1/4-inch letters for succeeding lines; except, in cases where the tag will not fit because the equipment is too small, use 3/16-inch letters for the first line and 1/8-inch letters for succeeding lines.

2.04 CONDUIT AND RACEWAY LABELS

A. Conduit Voltage Markers:
   1. Provide conduit markers consisting of polymer-coated cloth tape with a printable top coat and a rubber based pressure sensitive adhesive on the back to provide oil and water resistance, good print durability, and the flexibility to allow it to be wrapped around curved surfaces.
   2. Clearly mark the voltages in black lettering on orange colored tape backgrounds.

B. Conduit Wiring System Identification:
   1. Provide companion type labeling markers to indicate the wiring system in each raceway and consisting of a vinyl film substrate with a pressure sensitive acrylic adhesive backing.
   2. Clearly mark the wiring systems in black lettering on orange colored tape backgrounds.
   3. To properly identify each electrical system in the raceway, provide the following, or similar, wording on the labeling markers corresponding to the systems:
      a. For electrical power systems, word the labels "POWER".
      b. For control systems, word the labels "CONTROL".
      c. For local area networks, word the labels "LAN".

C. Conduit Feeder Identification:
   1. Provide conduit feeder identification markers consisting of polymer-coated cloth tape with a printable top coat and a rubber based pressure sensitive adhesive on the back to provide oil and water resistance, good print durability, and the flexibility to allow it to be wrapped around curved surfaces.
   2. Provide conduit feeder identification labels that identify the feeder circuit with 3/4-inch high black lettering on yellow backgrounds.

D. Conduit and Raceway Label Dimensions:
   1. Provide label color field lengths and lettering height as indicated in Table 26 05 23-1:

Table 26 05 23-1 Conduit and Raceway Label Sizes

Raceway Outside Diameter (Inches)	Background Length (Inches)	Lettering Height (Inches)
3/4 to 2	7	1
1-1/2 to 2	7	1
2-1/2 to 6	14	1-1/4

E. Product Examples:
   1. Conduit Voltage Markers: Brady Worldwide, Inc., B-946 custom self-sticking pipe markers or color code tape.
   2. Conduit Wiring System: Brady Worldwide, Inc., B-946 custom self-sticking pipe markers or color code tape.

3. Conduit Feeder Identification: Brady Worldwide, Inc., Product Number 31964.

PART 3 EXECUTION

3.01 PREPARATION

A. Prior to installing electrical identification items, verify with the Engineer that the data on each is correct.

3.02 INSTALLATION

A. Wiring Identification:
   1. Identify wiring in conformance with the requirements of Section 26 05 19.

B. Conduit and Raceway Identification:
   1. Identify the wiring systems in conduit and raceway by providing companion type labeling markers to indicate the systems in each.
   2. Identify the Voltages carried in conduit and raceway by providing voltage labeling markers on all accessible raceways.
   3. Identify feeders by providing identification labels.
   4. Label each conduit at minimum on each end of the conduit run, one other location in each room/area, distance between labels shall not exceed 50’.

C. Electrical Box Identification:
   1. For each pull box and junction box, if it is not otherwise indicated, install a laminated phenolic identification nameplate with 1/8-inch white letters on a black background] above or next to the box identifying its source of power; for example, indicate the panelboard and circuit number supplying power to a box with an identification nameplate.
   2. For each device and outlet box used as a branch circuit junction or pull box provide a legible hand written panel designation and circuit number on exterior of box cover. Utilize a permanent black marker.
   3. For above ground pull boxes and junction boxes, install nameplates adjacent to or above the item in a visible location.
      a. For NEMA 1 and 12 enclosures constructed as specified in NEMA 250, fasten the nameplate to the enclosure using 316 stainless steel screws or an approved equal.
      b. For other than NEMA 1 and 12 enclosures, fasten the nameplate to the enclosure using Seton number15660 adhesive or an approved equal.
   4. For in-ground pull boxes and junction boxes, install nameplates adjacent to or above the item in a visible location and inside the box immediately below the cover.
      a. For NEMA 1 and 12 enclosures constructed as specified in NEMA 250, fasten the nameplate to the enclosure using 316 stainless steel screws or an approved equal.

b. For other than NEMA 1 and 12 enclosures, fasten the nameplate to the enclosure using Seton number15660 adhesive or an approved equal.

D. Wiring Device Faceplate Labeling
1. Outside of faceplate:
a. On receptacle faceplates, provide a label indicating panel designation and circuit number. Utilize a thermal label maker device with clear label tape, font color shall be black and type shall be Arial.
2. Inside of faceplate:
a. On receptacle and lighting control device faceplates, provide a legible hand written panel designation and circuit number tag. Utilize a permanent black marker.

E. Electrical Equipment Identification:
1. Provide identification nameplates on the front of the following electrical equipment:
a. Low-voltage enclosed switches as specified in Section 26 28 16.13.
b. Low-voltage transformers as specified in Section 26 22 00.
2. Install nameplates in the top center of the front face of the electrical equipment in a visible location.
a. For NEMA 1 and NEMA 12 enclosures constructed as specified in NEMA 250, fasten the nameplate to the enclosure using 316 stainless steel screws or an approved equal.
b. For other than NEMA 1 and 12 enclosures, fasten the nameplate to the enclosure using Seton number15660 adhesive or an approved equal.
3. Provide a manufacturer installed mimic bus; field installed mimic buses are not acceptable.

END OF SECTION

SECTION 26 05 63

ACCEPTANCE TESTING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: The work specified in this Section consists of materials to performance test electrical systems and equipment.
   1. Items Supplied Under This Section:
      a. Electrical System Testing
      b. Thermographic Testing
      c. Ground System Testing
      d. Insulation Testing
      e. Equipment Testing
      f. Performance Test
      g. Test Procedure
      h. Test Report

B. Related Sections:
   1. Division 01 Sections, as Applicable
   2. Division 26 Sections, as Applicable

1.02 REFERENCES

A. Applicable Documents and Testing Requirements of:
   1. America National Standards Institute (ANSI): as applicable, including:
      a. ANSI C2, National Electrical Safety Code.
      b. ANSI Z244.1 American National Standards for Personnel Protection.
   2. National Electrical Manufacturer's Association (NEMA): as applicable, including:
      a. NEMA ICS 2.3 - Instructions for the Handling, Installation, Operation and Maintenance of Motor Control Centers.
      b. NEMA ICS 7.1 - Safety Standards for Construction and Guide for selection, Installation, and Operation of Adjustable Speed Drive Systems.
      c. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
      d. NEMA PB 2.1 - Proper Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts or Less.
   3. American Society for Testing and Materials (ASTM), as applicable.
   4. Institute of Electrical and Electronics Engineers (IEEE), as applicable, including:
      a. IEEE C.57.13, IEEE Standard Requirements for Instrument Transformers.
   5. National Fire Protection Association (NFPA), as applicable, including:
      a. NFPA 70 - National Electrical Code (NEC).
      b. NFPA 70E - Electrical Safety Requirements for Employee Workplaces.
      c. NFPA 72 - National Fire Alarm Code (NFAC).

6. Insulated Cable Engineer's Association (ICEA), as applicable.
7. State and Local Codes and Ordinances as applicable
8. Occupational Safety and Health Administration (OSHA), as applicable, including: Title 29, Parts 1907, 1910 and 1936.
9. International Electrical Testing Association (NETA) as applicable, including:
   a. ATS-2013: Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems.
   b. MTS-2013: Maintenance Testing Specifications for Electric Power Distribution Equipment and Systems.

1.03 SUBMITTALS

A. Submit documentation as required by this Section of the Contract to the Design Engineer in strict accordance with the provisions of Section 26 05 00 for review, comments and subsequent approval.

B. Submission to include the following:
   1. Field inspection report as required for each item of material and/or equipment outlined herein.

C. Test Reports:
   1. Each test report prepared by the respective testing firm(s) comply, where applicable, to all stipulations specified in Section 26 05 00 for Operation, Maintenance and Installation Manuals with reference to preparation, paper requirements, indexing and binders. Include in each test report the following:
      a. Summary of project.
      b. Description of equipment tested.
      c. Description of test.
      d. Test results.
      e. Conclusions and recommendations.
      f. Appendix, including appropriate test forms.
      g. Identification of test equipment used.
      h. Signature of responsible test organization authority.
      i. Furnish five copies of each completed report to the Design Electrical Engineer no later than 30 days after completion of each test. Assemble and certify the testing firm each final test report, which must be submitted to the Design Engineer for review, comments and subsequent approval.

1.04 QUALITY ASSURANCE

A. Qualifications of Testing Laboratory: Select an independent nationally recognized testing laboratory that is independent from electrical contractor that either is a member of The International Electrical Testing Association or meets the following qualifications:
   1. Is nationally recognized as an electrical testing laboratory.

2. Has been regularly engaged in the testing of electrical systems and equipment for at least 2 years.
3. Is independent from the electrical contractor, the Owner, the Engineer and all other contractors on the job.
4. Has at least one Professional Engineer on staff that is licensed in the State where the project site is located.
5. Derives more than 75 percent of its income from electrical testing.
6. Owns or leases sufficient calibrated equipment to do the testing required.
7. Has a means to trace all test instrument calibration to The National Institute of Standards and Technology.

B. Membership in the International Electrical Testing Association (NETA) shall be considered evidence of meeting items A. 1. through and including A. 5

C. Testing shall be done under the supervision of a technician certified by International Electrical Testing Association or by technicians that are both certified by the National Society of Professional Engineers and experienced in electrical testing with 5 years of testing experience.

D. The testing laboratory shall supervise or perform all testing of equipment and oversee setting of all circuit breakers and calibration of all instruments.

E. The testing firm used must be approved by the Engineer.

F. Include the cost of such tests in the Contractors Bid Price for the applicable bid item.

1.05 GENERAL REQUIREMENTS

A. Field Inspection:
1. This Contractor is responsible for a complete inspection of all equipment, prior to testing and energizing to ascertain that it is free from any damage, scratches, or missing components and that all power connections are correct, and that they are tight in conformance with recommended standard practice. The inspection is to also include a check of control wiring, terminal connections and all bolts and nuts.
2. Perform field inspection by this Contractor during a time when the Field Engineer and the Design Engineer are present to witness each inspection and its performance.
3. Correct any deficiencies found during the inspection by this Contractor prior to the energizing and testing of the equipment.

1.06 SCHEDULING

A. Schedule all testing with work of other contractors to ensure an orderly sequence of startup and completion of work.

1.07 UNDERGROUND CONDUIT SYSTEM INSPECTION

A. General Requirements: Perform inspection of the underground conduit systems installation by a representative of the Engineer as the work progresses. Inspect each of the following prior to proceeding to the next phase of the installation.
   1. Trench bed.
   2. Lower sand bed.
   3. Lower concrete protection slab, where indicated or required.
   4. Upper sand bed for conduits.
   5. Each layer of conduits.
   6. Soil backfill.
   7. Warning Tape.
   8. Soil backfill.

B. Failure to comply with any of the above, indicated sequential inspection requirements is just cause for the Engineer to request removal of the work and reinstall as per these specifications.

PART 2 PRODUCTS

NOT USED

PART 3 EXECUTION

3.01 ELECTRICAL INSPECTIONS AND TESTS

A. Perform, supervise, and furnish all test equipment needed to perform tests and provide safety measures, procedures and equipment required for each test.

B. Schedule all testing with the Engineer. Perform testing in the presence of the Engineer except when the Engineer approves in writing conducting a specific test without the Engineer's presence.

C. Notify all involved parties including the Engineer prior to tests, advising them of the test to be performed and the scheduled date and time.

D. Coordinate the tests with others involved.

E. Prepare written test procedures and forms used in the test reports and submit for approval prior to commencement of testing.

F. Include in each test report the following information:
   1. Job title.
   2. Date of test.
   3. Equipment, system or cable identification.
   4. Type of test.
   5. Description of test instrument and date of latest calibration.

6. Section of specification defining test along with description of test and evaluations as reported by the testing company.
7. Test results (correct all readings at 20 degrees C).
8. Signature of person supervising test.
9. Signature of Contractor.
10. Space for Engineer's signature.

G. Refer to individual tests and inspections hereinafter specified for any additional or specified requirements.

H. Test Instrument Calibration:
1. The testing firm is to have a calibration program, which assures that all applicable test instrumentation are maintained within rated accuracy.
2. The accuracy is to be directly traceable to The National Institute of Standards and Technology.
3. Instruments are to be calibrated in accordance with the following frequency schedule.
   a. Field Instruments: Analog - 6 months maximum
      Digital - 12 months maximum
   b. Laboratory Instruments: 12 months
   c. Leased specialty equipment: 12 months
4. Make dated calibration labels visible on all test equipment.
5. Keep records up-to-date, which show date and results of instruments calibrated or tested.
6. Maintain an up-to-date instrument calibration instruction and procedure for each test instrument.
7. Calibrating standard is to be of higher accuracy than that of the instrument tested.

I. Safety and Precautions:
1. Safety practices are to include, but are not limited to, the following requirements:
   a. Occupational Safety and Health Act of 1970-OSHA.
   b. Accident Prevention Manual for Industrial Operations, National Safety Council, Chapter 4.
   c. Applicable State and Local safety operating procedures.
   d. IETA Safety/Accident Prevention Program.
   e. Owner's safety practices.
   f. National Fire Protection Association - NFPA 70E.
   g. ANSI Z244.1 American National Standards for Personnel Protection.
2. Perform all tests with apparatus de-energized except where otherwise specifically required.

3. The testing firm is to have a designated safety representative on the project to supervise operations with respect to safety.

3.02 TESTING TO BE PERFORMED BY THE CONTRACTOR

A. The Contractor is required to obtain copies of NETA ATS-2013 and MTS-2013, and to keep at least one copy of each at the project site, to use as reference for testing requirements.

B. Continuity Test: Make test for continuity and correctness of wiring and identification on all conductors installed.

C. Wire and Cable:
   1. Test all wires and cables sized No. 2 and larger in accordance with NETA ATS-2013.
   2. Perform visual, mechanical, and electrical tests on all No. 4 and No. 6 power cables that operate at voltages exceeding 150 volts to ground in accordance with NETA ATS-2013.
   3. Perform visual, mechanical, and electrical tests on all other wires and cables in accordance with NETA ATS-2013.
   4. Replace any wires which have been damaged.
   5. Correct causes of all readings which do not meet the acceptable minimum insulation readings are as stated in NETA ATS-2013. Exceed the nominal expected temperatures for the actual load.
   6. Retest items requiring correction.

D. Ground Fault Circuit Interrupter (GFCI) Receptacles:
   1. Test all GFCI receptacles as specified in Section 26 27 16.

E. Lighting Tests
   1. Operate new battery systems for emergency lighting without power for 90 minutes and correct all defects and retest.

3.03 TESTING TO BE PERFORMED BY THE TESTING LABORATORY

A. Select, hire and pay an independent nationally recognized electrical testing laboratory to perform all testing specified in this article. Obtain Owner's approval of the testing laboratory and the testing laboratory proposed test procedure prior to commencement of any tests.

B. Thermographic Inspection:
   1. Perform thermographic inspection of the electrical equipment and installations as listed below in accordance with NETA ATS-2013, and as detailed below. The following equipment is to be scanned:
      a. Service Entrance Panelboards — all ratings
      b. Distribution Panelboards — 50-Ampere and larger
      c. Lighting Panelboards — 50-Ampere and larger
      d. Power Panelboards — 50-Ampere and larger
      e. Dry Type Transformers — 10 kVA and Larger

f. Disconnect Switches 100 amp and larger
g. Individually Mounted Motor Starters Size 1 and larger

2. Provide report including the following items:
   a. Items scanned
   b. Whether item passed or failed
   c. All items in NETA ATS-2013
   d. The probable cause
   e. Severity of defect
   f. Recommended corrective measures
   g. Video recording of test.
3. Scan using an infrared camera with video scanner output to a display screen with a range of at least 1 degree C to 75 degrees C with an accuracy of 0.1 degree C and with the following equipment:
   a. One 7 degree telephoto lens
   b. One 20 degree wide angle lens
   c. One 40 degree extra-wide angle lens
4. Record output of camera during testing onto a DVD or store digital images of each piece of equipment inspected onto a CD as a record of the temperature variations. Record either by order or by digital imprinting the actual equipment being scanned. Turn off recordings during inactive periods or edit DVD to eliminate dead periods.
5. Display data on a monitor capable of providing both a gray step mode and color monitor. These capabilities allow distinct temperature levels to be shown in black and white and color on the thermogram.
6. Submit three copies of report and two copies of the DVD or CD.
7. Include DVD or CD of thermographs of the defective equipment and installations. Also include in report.
8. Submit both copies of the report to the Engineer who will make the determination of corrective measurements.

C. Dry-Type Transformers Tests:
   1. Visually and mechanically inspect and electrically test low voltage dry-type transformers in sizes rated over 7.5 kVA, 3-phase and rated less than 500 kVA, 3-phase in accordance with NETA ATS-2013.
   2. Acceptable test values are as stated in NETA ATS-2013.

D. Voltage Adjustment:
   1. Measure the plant voltage with the plant operated at both no load and at nominal load at the following locations.
      a. Bus Wash panelboard bus.
      b. Bus Wash 480V Control Panels
   2. Adjust all transformer taps to bring the no-load voltage above nominal, but in no case, higher than 105.8% of nominal. Adjust the operated loaded voltage to a value above 91.7%, (ANSI Range A), with only momentary excursions to a

maximum of 105.8% and a minimum of 88.3% for all loads and 86.7% for motor loads. (ANSI Range B).

3. After all adjustments have been made, re-measure all voltages.

3.04 CORRECTION OF DEFICIENCIES

A. Report all unacceptable values immediately. Correct all deficiencies found in work of this contract and separately report deficiencies in work of items of other contracts.
   1. Retest items requiring correction. Correct or have corrected any remaining deficiencies and retest until work is acceptable.

END OF SECTION

SECTION 26 22 00

LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: The work specified in this Section consists of material for furnishing, installing, connecting, energizing, testing, cleaning and protecting transformers.

B. Related Section:
1. Section 26 05 00 - Common Work Results for Electrical.
2. Section 26 05 26 - Grounding and Bonding for Electrical Systems
3. Section 26 05 63 – Acceptance Testing of Electrical Systems
4. Section 26 05 33.13 – Conduits for Electrical Systems.

1.02 REFERENCES

A. Institute of Electrical and Electronic Engineers/American National Standards Institute (IEEE/ANSI):

1.	IEEE/ANSI C57.12.01	General Requirements for Dry-type Distribution and Power Transformers
2.	IEEE/ANSI C57.12.59	Guide for Dry-type Transformer Through-Fault Current Duration.
3.	IEEE/ANSI C57.12.70	Terminal Markings and Connections for Power and Distribution Transformers.
4.	IEEE/ANSI C57.12.80	Standard Terminology for Power and Distribution Transformers.
5.	IEEE/ANSI C57.12.91	Test Code for Power and Distribution Transformers.
6.	IEEE/ANSI C57.94	Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type General Purpose Distribution and Power Transformers.
7.	IEEE/ANSI C57.96	Guide for Loading Dry-Type Distribution and Power Transformers.

B. National Electric Manufacturer's Association (NEMA):

1.	NEMA ST 20	Dry Type Transformers for General Applications.
2.	NEMA TR 1	Transformers, Regulators, and Reactors.

C. Underwriter’s Laboratory, Inc. (UL):

1.	UL 1561	Transformers, Dry-Type General Purpose and Power.

D. National Fire Protection Association (NFPA):
   1. NFPA 70 National Electrical Code (NEC).

1.03 DEFINITIONS

A. Definitions of terms are as indicated in NFPA 70, IEEE/ANSI C57.12.80 and NEMA ST 20 unless otherwise indicated, noted or specified.

1.04 SYSTEM DESCRIPTION

A. Design Criteria:
   1. Provide transformers with ratings as indicated.
   2. Provide transformers designed for the following conditions:
      a. 40 degrees C. maximum ambient temperature.
      b. -20 degrees C. minimum ambient.
      c. 1,000 feet above sea-level.
      d. Indoors unless otherwise indicated or specified.

B. Provide transformers for connecting to the following systems with nominal voltages and operating ranges as specified in IEEE/ANSI C84.1:
   1. 480Volt, 3-phase, 3-wire, grounded or ungrounded.

C. Provide transformers for supplying the following systems with nominal voltages and operating ranges as specified in IEEE/ANSI C84.1
   1. 208/120 Volt, 3-phase, 4-wire, grounded wye.

D. Provide transformers for connecting to systems with a let-through fault capability up to the limits of IEEE/ANSI C57.12.59.

1.05 SUBMITTALS

A. Testing Agency/Quality Verification: Provide with all product data evidence of testing agency/quality verification, listing, and labeling either by printed mark on the data or by a separate listing card. Provide from product manufacturers a written statement indicating why an item does not have a quality assurance verification. Such statements are subject to the approval of the Engineer.

B. Product Data:
   1. List of transformers and accessories to be furnished and installed.
   2. Catalog cuts of all transformers and accessories.

C. Shop Drawings: Provide shop drawings for the following:
   1. Complete outline drawing, showing overall length, width, and height and including ratings of equipment, impedance, and installation restrictions.

D. Submit Operation and Maintenance Manual.

1.06 QUALITY ASSURANCE

A. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory unless products meeting the requirements of these testing laboratories are not readily available or unless standards do not exist for the products. Provide products that are listed and labeled or approved as stated above for the location installed in and listed and labeled or approved as indicated and specified for the applications the items are intended for.

B. Conform all work to NFPA 70, National Electrical Code.

C. Install work under supervision of skilled licensed electricians.

PART 2 PRODUCTS

2.01 SECONDARY TRANSFORMERS

A. Provide transformers of the general purpose, indoor, double-wound, ventilated, dry-type designed and tested in accordance with NEMA Standard ST 20 and ANSI Standard C57.12.01, Underwriter's Laboratories Standard UL-1561, and ANSI C57.12.91 of capacities and mounting arrangements, (floor or wall) as indicated on the Drawings. Provide wall-mounted transformers with the wall bracket that is adequate for the supporting weight.

B. Design transformers for continuous operation at rated KVA, 24 hours a day, 365 days a year, with normal life expectancy as defined in ANSI/IEEE C57.96. Provide a transformer which will make this performance obtainable without exceeding 150 degree C. average temperature rise by resistance or 180 degree C. hot spot temperature rise in a 40 degree C. maximum ambient and 30 degree C. average ambient. Do not exceed 220 degree C as the maximum coil hot spot temperature.

C. Provide proven 220 degree C. insulation systems.

D. Wind the coils with copper, which has insulated, proven, high temperature resistant, 220 degree C. materials.

E. Use all materials in the transformer that are flame retardant and do not support combustion as defined in ASTM Standard Test Method D635.

F. Totally immerse the transformer in an insulating varnish, which will maintain superior bond strength, high dielectric strength, and outstanding power factors at temperatures associated with the 220 degree C. system as a final insulation treatment. After immersion, cure the varnish at normal operating temperatures for such a period of time as to assure complete curing of the varnish and scourging of volatiles in the varnish solvent.

G. Construct transformers with core materials of a high quality, low loss nature as to minimize exciting current, no-load losses, and interlaminar vibrations.

H. The core and coil assembly shall be installed on vibration-absorbing pads.

I. Transformer average sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings:
   1. Up to 9 kVA 40 db
   2. 10 to 50 kVA 45 db
   3. 51 to 150 kVA 50 db
   4. 151 to 300 kVA 55 db
   5. 301 to 500 kVA 60 db
   6. 501 to 700 kVA 62 db
   7. 701 to 1000 kVA 64 db
   8. 1001 to 1500 kVA 65 db

J. Design the core-coil assembly and mechanically brace to withstand short circuit tests as defined in ANSI C57.12.91 by the use of full-scale testing. The coil construction and mechanical bracing members shall be such as to prevent mechanical degradation of the insulation structures during short circuit.

K. Provide single phase transformers 2 KVA and below without taps. Provide 3 KVA and 5 KVA with 2-2 ½ percent above nominal full capacity (ANFC) and 2-2 ½ percent below nominal full capacity (BNFC) taps. Provide 7-1/2 KVA and above with 2-2 ½ percent ANFC and 4-2 ½ percent BNFC taps.

L. Provide three phase transformers with 2-2 ½ percent ANFC and 4-2 ½ percent BNFC taps.

M. Provide transformer with enclosures removable front and back panels and must have screened or grilled ventilation openings designed to prevent accidental access to electrified parts.

N. The following factory tests shall be made on all transformers:
   1. Ratio tests at the rated voltage connection and at all tap connections.
   2. Polarity and phase relation tests on the rated voltage connection.
   3. Applied potential tests.
   4. Induced potential tests.
   5. No-load and excitation current at rated voltage on the rated voltage connection.

O. Transformers shall be low loss type with minimum efficiencies per NEMA TP-1 when operated at 35% of full load capacity.

P. Acceptable Manufacturers:
   1. Square D Company
   2. Eaton Electric

3. Siemens Industry for LV Power Distribution

PART 3 EXECUTION

3.01 INSTALLATION

A. Install, connect, and interconnect products where indicated, and in accordance with NEMA Standards, manufacturer's printed installation instructions, and this Section. Make connections in a manner, which will insure electrical continuity and operability of the products.

B. Protect the equipment against foreign matter and moisture during installation.

C. Install a 3-foot (1m) length of liquid-tight flexible metal conduit between transformer and fixed conduit system in accordance with Section 26 05 33.13. Make power conductor connections in accordance with manufacturer's drawings, and as indicated on the Drawings.

D. Ground in accordance with Section 26 05 26. Provide ground bond for enclosure and neutral, minimum size #6 AWG to nearest structural steel to conform with Section 26 05 26 and the NEC.

3.02 FIELD QUALITY CONTROL

A. Dry out dry type transformers before they are energized.

B. Check transformer for tightness of external structural members and mechanical joints in order to minimize audible sound levels. Check the ground connections.

C. Test as specified in Section 26 05 63.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: The work specified in this Section consists of all materials for furnishing, installing connecting, energizing, testing, cleaning and protecting wall-mounted panelboards.

B. Related Section:
1. Section 26 05 00 – Common Work Results
2. Section 26 05 19 - Low Voltage Electrical Power Conductors and Cables
3. Section 26 05 28 – Hangers and Supports for Electrical Systems
4. Section 26 05 53 – Identification for Electrical Systems
5. Section 26 05 63 – Acceptance Testing of Electrical Systems

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM):
1. ASTM B164 Nickel-Copper Alloy, Bar and Wire.
2. ASTM B187 Standard Specifications for Copper Bus, Bus Bar, Rod and Shapes

B. National Electrical Manufacturers Association (NEMA):
1. NEMA 250 Electrical Enclosures.
2. NEMA AB 1 Molded Case Circuit Breakers and Molded Case Switches.
3. NEMA AB 2 Molded Case Circuit Breakers and their Application.
4. NEMA PB 1 Panelboards.
5. NEMA PB 1.1 General Instructions for Proper installation, Operation, and Maintenance of Panelboards.

C. National Fire Protection Association (NFPA):
1. NFPA 70 National Electrical Code (NEC).

D. Underwriters Laboratories (UL):
1. UL 489 Molded Case Circuit Breakers and Circuit Breaker Enclosures
2. UL 50 Cabinets and Boxes
3. UL 67 Panelboards

1.03 SYSTEM DESCRIPTION

A. Existing Panelboards are connected to system voltages as follows:
   1. 208Y/120 Volt, 3-phase, 4-wire.

1.04 SUBMITTALS

A. Testing Agency/Quality Verification: Provide with all product data evidence of testing agency/quality verification, listing, and labeling either by printed mark on the data or by a separate listing card. Provide from product manufacturers a written statement indicating why an item does not have a quality assurance verification. Such statements are subject to the approval of the Engineer.

B. Product Data and Catalog Cuts: Provide product data for all products provided. Indicate clearly the usage and designation of each product.

C. Shop Drawings: Submit shop drawings for all new panelboard circuit breakers along with information on the existing panelboards to ensure compatibility.

1.05 QUALITY ASSURANCE

A. Conform all work to NFPA 70, National Electrical Code.

B. Install work under supervision of licensed electricians

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Basic Electrical Materials: Those products such as conduit, wireways, wire and connectors, cable, support devices, fasteners, and similar devices as required for work of this Section are as specified in other Sections of these Specifications.

2.02 PANELBOARD – NEW CIRCUIT BREAKERS

A. Molded case circuit breakers:
   1. Provide inverse time and instantaneous tripping characteristics.
   2. Provide trip ratings, frame sizes, and number of poles as indicated, scheduled, and noted on the Drawings.
   3. Provide full rated circuit breakers with short circuit ratings equal to the panelboard installed as scheduled on the Drawings.
   4. Provide molded case circuit breakers conforming to NEMA AB 1, and UL 489.
   5. Provide circuit breakers of the same manufacture and type as the panelboard installed.
   6. New circuit breakers for existing panelboards shall match the existing circuit breaker type, manufacturer, and AIC rating. Circuit breakers that are added into

existing equipment shall be new, unless noted on the drawings as existing to be relocated and/or reused; and shall be purchased from an authorized manufacturer's distributor. Purchase of used, reconditioned, or brokered circuit breakers is prohibited unless approved by the Engineer.

B. Acceptable Manufacturer:
   1. Square D Company

PART 3 EXECUTION

3.01 INSTALLATION

A. Install all circuit-breakers in accordance with the manufacturer's instructions and NEMA PB 1.1.

B. Punch holes for conduit entries in the enclosures.

C. At the end of the project update the circuit directories to reflect as-built conditions. Circuit directions shall be typed.

3.02 CLEANING

A. After wiring, vacuum out interior and wipe clean of all foreign material.

B. After painting in areas, remove all over paint, drips and splashes.

3.03 PROTECTION

A. During painting, mask all nameplates, all plastic parts, and all items not to be painted.

B. Protect all items during work of other trades including welding and cutting.

C. Protect panelboards against overloads, short circuits, and improper operation, padlock off when work is being done on downstream circuits.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Requirements for furnishing, installing, connecting, energizing, testing, cleaning, and protecting wiring devices and cover plates.

B. Related Sections:
   1. Division 01 Sections, as Applicable
   2. Section 26 05 00 - Common Work Results for Electrical.
   3. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
   4. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
   5. Section 26 05 28 - Hangers and Supports for Electrical Systems.
   6. Section 26 05 33.13 – Conduits for Electrical Systems.
   7. Section 26 05 33.23 – Boxes for Electrical Systems.
   8. Section 26 05 53 – Identification for Electrical Systems.
   9. Section 26 05 63 – Acceptance Testing of Electrical Systems.

1.02 REFERENCES

A. National Electric Manufacturer's Association (NEMA):
   1. NEMA WD 1 - General Color Requirements for Wiring Devices.
   2. NEMA WD 6 - Wiring Devices - Dimensional Requirements.

B. National Fire Protection Association (NFPA):
   1. NFPA 70 - National Electrical Code (NEC).

C. Underwriter’s Laboratories, Inc. (UL):
   1. UL 20 - Standard for Safety for General-Use Snap Switches.
   2. UL 231 - Standard for Power Outlets.
   3. UL 498 - Standard for Safety for Attachment Plugs and Receptacles.
   4. UL 943 - Standard for Safety for Ground-Fault Circuit-Interrupters.
   5. UL 1449 - Standard for Transient Voltage Surge Suppressors.
   6. UL 1681 - Standard for Safety for Wiring Device Configurations.

1.03 DEFINITIONS

A. Definitions for all items are as stated in NFPA 70 and the other references listed unless otherwise stated, specified, or noted.

B. SPDT: An acronym for single pole, double throw type electrical switches.

C. Wiring Devices: Yoke mounted switches and receptacles with indicated line ratings of 300 Volts and 30 Amperes or less.

1.04 DESIGN REQUIREMENTS

A. Provide electrical power outlets designed in accordance with the requirements of UL 231 and UL 1681.

B. Product Data:
   1. Submit a list of the products and accessories proposed to satisfy the requirements of this Section.
   2. Submit Product Data and catalog cuts of the materials and equipment proposed to be used to satisfy the requirements of this Section.
      a. Clearly indicate the usage of each product on the submittal.

1.05 SUBMITTALS

A. Submit the following information to the Engineer for approval in accordance with the requirements of Section 01 33 00, Submittal Procedures:
   1. Product Data:
      a. List of the proposed materials.
      b. Catalog cuts of toggle handle snap switches.
      c. Catalog cuts of control switches.
      d. Catalog cuts of dimmer switches.
      e. Catalog cuts of emergency power shut-off switches.
      f. Catalog cuts of heavy duty specification grade receptacles.
      g. Catalog cuts of power outlet receptacles.
      h. Catalog cuts of device plates and covers.
   2. Quality Assurance/Control Submittals:
      a. Test Reports.
         1) Test reports for Site tests.
      b. Certificates.
         1) Testing agency/quality verification, listing, and labeling.
      c. Manufacturers Instructions.
         1) Manufacturer's printed installation instructions.
      d. Qualification Statements.
         1) Qualifications of the Electrical Testing Laboratory (ETL).

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Electrical Testing Laboratory (ETL) Qualifications:
      a. Employ an independent testing agency, qualified as specified in Section 01 40 00, Quality Requirements, and Section 26 05 63, Acceptance Testing of Electrical Systems, to perform testing required by this Section.
      b. Submit information verifying the ETL’s qualifications.

B. Regulatory Requirements:
   1. Perform the Work of this Section in accordance with the requirements specified in NFPA 70, and to all other applicable state, local, and national governing codes and regulatory requirements.

C. Certifications:
   1. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory (ETL) for the location installed in, and the application intended, unless products meeting the requirements of these testing laboratories are not available or unless standards do not exist for the products.
      Provide copper conductors listed and labeled by UL for all wiring.
   2. Submit evidence of testing agency/quality verification, listing, and labeling for each product with the submitted product data either by providing a printed mark on the data or by attaching a separate listing card.
      a. For items without such evidence, submit a written statement from the product manufacturer that indicates why it does not have quality assurance verification.

1.07 MATERIAL DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling, and Unloading:
   1. Pack, ship, handle, and unload products in accordance with the requirements of Section 26 05 00, Common Work Results for Electrical.

B. Acceptance at Site:
   1. Accept products at the Site in accordance with the requirements of Section 26 05 00, Common Work Results for Electrical.

C. Storage and Protection:
   1. Store products in accordance with the requirements of Section 26 05 00, Common Work Results for Electrical.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Use of Trade Names:
   1. The use of trade names within the Contract Documents is intended to establish the basis of design and to illustrate the constructability and level of quality required.
   2. The use of trade names is not intended to exclude other manufacturers whose products are equivalent to those named, subject to compliance with Contract requirements.

B. Provide the switches and receptacles of the same kind provided under this Contract from the same manufacturer; a mixture of manufacturers= products is unacceptable.

2.02 MANUFACTURED UNITS

A. Switches:
   1. Provide UL listed specification grade switches meeting the requirements of W-S-896F, NEMA WD 1, and NEMA WD 6 for the voltage and current indicated, and having screw terminals.
   2. Toggle Handle Snap Switches:
      a. Provide quiet design, 20 Amp rated, single pole, 3-way or 4-way, toggle handle snap switches as indicated in the Contract Documents.
      b. Control Switches:
         1) For control switches, provide SPDT switches with center OFF and maintained contacts, or SPDT with center OFF and momentary contacts, of the same basic type, construction, and rating as specified for other toggle handle snap switches.
         2) Provide switch with terminals rated for both solid and stranded wire.
         3) See the Contract Drawings for additional information.
      c. Manufacturers:
         1) Hubbell
            a) Heavy Duty Specification Grade Switches: HBL1220 Series.
            b) Construction Series Heavy Duty Specification Grade Switches: CS120 Series.
         2) Pass & Seymour
         3) Leviton Manufacturing Co.
         4) Approved equal.

B. Receptacles:
   1. Provide UL listed specification grade receptacles complying with the requirements of W-C-596/40D, W-C-596/41D, W-C-596/107A, NEMA WD 1, and NEMA WD 6 for the voltage and current indicated, and having screw terminals.
      a. Provide receptacles complying with the terminal identification requirements of UL 498.
   2. Standard Face Design Receptacles:
      a. Heavy Duty Specification Grade Receptacles:
         1) Provide 2-pole, 3-wire, grounding type duplex receptacles rated for 125 Volts AC and 20 Amperes.
         2) Provide receptacles with terminals rated for both solid and stranded wire.
         3) Manufacturers:
            a) Hubbell, HBL5352 Series
            b) Pass & Seymour
            c) Leviton Manufacturing Co.
            d) Or Approved equal.
   3. Ground Fault Circuit Interrupter (GFCI) Receptacles:
      a. Heavy Duty Specification Grade GFCI Receptacles:

1) Provide 2-pole, 3-wire, grounding type duplex GFCI receptacles rated for 125 Volts AC and 20 Amperes; having solid state circuitry; and that comply with the requirements of UL 498 and UL 943.
2) Provide receptacles with terminals rated for both solid and stranded wire.
3) Manufacturers:
   a) Hubbell, GFR5362TR Series
   b) Pass & Seymour
   c) Leviton Manufacturing Co.
   d) Approved equal.

4. Power Outlet Receptacles:
   a. Provide heavy-duty, polarized, grounding type power outlet receptacles rated for the voltage and amperage indicated in the Contract Documents.
   b. Provide receptacles with terminals rated for both solid and stranded wire.
   c. Manufacturers:
      1) Hubbell, Twist-Lock and straight blade
      2) Pass & Seymour
      3) Leviton Manufacturing Co.
      4) Approved equal.

2.03 ACCESSORIES

A. Wall Plates:
   1. Unless otherwise indicated in the Contract Documents, provide AISI Type 302/304 stainless steel wall plates.
      a. For use with exposed stamped steel boxes and cast type boxes, provide heavy cadmium-plated steel wall plates whose edges are flush with the edges of the associated boxes.
      b. For pushbutton or buzzer outlet boxes, provide wall plates having openings to suit the pushbuttons or buzzers.
      c. For locations subject to wet or rain conditions, provide wet location wall plates marked with the words “Suitable for Wet Locations While in Use”.
   2. Thickness (Minimum): 0.040 inches thick (1mm).
   3. Finish:
      a. For finished areas, provide wall plates having a satin finish.
      b. For emergency circuits, provide either a red or Type 302/304 stainless steel wall plate engraved with the word “EMERGENCY” and with the panel designation and circuit number.
   4. Fasteners:
      a. For installing wiring devices and wall plates, provide the following of fastener types:
         1) For affixing metal wall plates, provide plated screws except as follows:
            a) For other than dry locations, provide stainless steel hardware.
   5. Manufacturers:
      a. Hubbell
      b. Pass & Seymour

c. EGS/Appleton Electric
d. EGS/O-Z/Gedney
e. Cooper Crouse-Hinds
f. Approved equal.

B. Weatherproof Cast Covers:
1. Provide with vertical cast construction, baked-on electrostatic polyester and powder paint for scratch/corrosion resistance.
2. Provide toggle switch cover with On/Off position designation indicated on cover.
3. Provide with heavy duty gasket that provides weatherproofing between cover plate and box.
4. Manufacturers:
a. EGS/Appleton Electric
b. EGS/O-Z/Gedney
c. Hubbell
d. Pass & Seymour
e. Leviton Manufacturing Co.
f. Approved equal.

C. Weatherproof While-In-Use Covers:
1. Body, cover and plates shall be made of polycarbonate and be non-conductive and non-corrosive.
2. A gasket shall be pre-applied that is constructed of closed-cell foam, neoprene blend regular density and UL rated HBF.
3. Cover shall provide a water channel, which keeps water moving outside while cord flap keeps the inside dry.
4. Cover shall be able to mount either vertically or horizontally.
5. Must provide a NEMA 3R protection level.
6. Manufacturers:
a. EGS/Appleton Electric
b. EGS/O-Z/Gedney
c. Hubbell
d. Pass & Seymour
e. Leviton Manufacturing Co.
f. Approved equal.

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect the surfaces of concrete foundations where wiring devices will be mounted to verify that the surface is level and complete.
1. Verify that the required number of anchors of the correct type and size have been placed in the proper locations.
2. Verify that there are no concrete spalls, honeycomb areas, or other concrete defects.

B. Verify that the pull and junction boxes installed are the correct type and size, and are at the correct location.
   1. Verify that flush boxes are plumb and level to within 1/8-inches of vertical and horizontal; and are either flush with the finish surface or protrude no more than 1/16 inch.
   2. Verify that surface mounted boxes are plumb and level to within 1/16-inch of vertical and horizontal.
   3. Verify that the size of each box conforms to the requirements of Article 370 of NFPA 70.

C. Verify that wiring pigtails within installed boxes are sufficiently long to re-terminate the wiring twice and still allow 6 inches of slack.

D. Verify that ground wires are the correct type and size, and are at the correct location.

3.02 PREPARATION

A. Correct defects discovered during the examination
   1. Remove any extraneous paint from the interior of boxes and from wiring.
   2. Clean the interior of boxes to remove dirt and debris.

B. Provide outlet boxes and supports for wiring devices in accordance with the requirements of Section 26 05 33.23, Boxes, and Section 26 05 28, Hangers and Supports.
   1. Mounting Locations and Heights:
      a. Unless otherwise specified or shown on the Contract Drawings, locate wiring devices by measuring the mounting heights from the finished floor to the centerline of the wiring device.
         1) Emergency Power Shut-Off Switches:
            a) Locate emergency power shut-off switches 5’- 0” above the finished floor on the hinge side of the exit door, or where shown on the Contract Drawings.
         2) Lighting Control Switches:
            a) Locate lighting control switches on the strike side of doors, and at 48-inches above the finished floor to the centerline of the switch, unless indicated otherwise on the Contract Drawings.
            b) Where it is not possible to mount lighting control switches side-by-side with a common device plate, mount them in tandem.
         3) Electrical Duplex Convenience Outlets:
            a) In Unfinished Areas:
               (1) Locate electrical duplex convenience outlets 36 inches above the finished floor, unless this interferes with equipment or another obstacle.
               (2) If locating electrical duplex convenience outlets 36 inches above the finished floor interferes with equipment or another

obstacle; then install the outlet above or below the obstruction as directed by the Engineer.

3.03 INSTALLATION

A. Install wiring devices and accessories in accordance with the manufacturer's printed installation instructions.
   1. Submit the manufacturer's printed installation instructions to the Engineer for information.
   2. Make connections to the devices in accordance with the requirements of Sections 26 05 19, Low-Voltage Electrical Power Conductors, and Section 26 05 33.13, Conduits for Electrical Systems.
   3. Ground the devices in accordance with the requirements of Section 26 05 26.

B. Provide a wall plate for each switch, receptacle, and special purpose outlet.
   1. If the Contract Drawings show two or more switches or receptacles at the same location, gang these devices together and cover them with a single wall or cover plate.
   2. For multi-gang boxes, provide multi-gang outlet plates; sectional gang plates are unacceptable.

C. Identify the wiring devices in accordance with the requirements of Section 26 05 53, Identification for Electrical Systems.
   1. Label emergency power shut-off switches appropriately.

3.04 REPAIR/RESTORATION

A. Correct the defects that are found in wiring devices during the specified inspections and tests, and retest the devices after correcting the defects.

3.05 FIELD QUALITY CONTROL

A. Site Tests:
   1. Test each receptacle with a plug-in tester that checks for reversed line and neutral wiring, reversed ground and neutral wiring, open ground wiring, and open neutral wiring.
   2. Verify that the GFCI receptacles work by using both the built-in integral tester and a plug-in tester which simulates a ground fault to test all receptacles.
   3. Test the last receptacle in each branch circuit to ensure that the neutral and ground wiring resistance does not exceed 1 ohm between the receptacle and its panelboard.
   4. Record and submit the results of the tests to the Engineer for approval in accordance with the requirements of Section 01 40 00, Quality Requirements.

B. Inspection:

1. Inspect boxes to verify proper operation, for visual appearance, and to verify correct mounting height.

3.06 ADJUSTING

A. Adjust the final position of switches and devices to be plumb and level, and set the final position of the wall plates for flush boxes flush to the wall.

3.07 CLEANING

A. Waste Management and Disposal:
   1. Clear and dispose of waste materials in accordance with the requirements of Section 26 05 00 Common Work Results for Electrical.

3.08 PROTECTION

A. Mask electrical devices to protect them from paint overspray or over-brushing during painting operations.

B. Protect electrical devices against damage from other work.

END OF SECTION

SECTION 26 28 16.13

LOW-VOLTAGE ENCLOSED SWITCHES

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Requirements for furnishing, installing, connecting, energizing, testing, cleaning, and protecting low-voltage enclosed disconnect switches, and fuses.

B. Related Sections:
   1. Section 26 05 00 – Common Work Results for Electrical.
   2. Section 26 05 28 - Hangers and Supports for Electrical Systems.
   3. Section 26 05 53 – Identification for Electrical Systems.
   4. Section 26 05 63 - Acceptance Testing of Electrical Systems.
   5. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

1.02 REFERENCES

A. InterNational Electrical Testing Association, Inc. (NETA):
   1. ANSI/NETA ETT Standard for Certification of Electrical Testing Technicians.

B. National Electrical Manufacturers Association (NEMA):
   1. NEMA 250; Enclosures for Electrical Equipment (1000 Volts Maximum).
   2. NEMA KS 1; Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).

C. National Fire Protection Association (NFPA):
   1. NFPA 70; National Electrical Code (NEC).

D. Underwriter’s Laboratories, Inc. (UL):
   1. UL 98; Standard for Enclosed and Dead-Front Switches.

1.03 SUBMITTALS

A. Submit the following information for approval in accordance with the requirements of Division 01:
   1. Product Data:
      a. Enclosed disconnect switches
      b. Fuses
   2. Shop Drawings:
      a. Enclosed disconnect switches
   3. Quality Assurance/Control Submittals:
      a. Certificates:
         1) Testing agency/quality verification listing cards, if required

2) Manufacturers written statement indicating why items do not have quality assurance verification, if required
b. Manufacturer's instructions:
1) Enclosed disconnect switches
c. Qualification Statements:
1) Electrical testing laboratory's qualifications

1.04 QUALITY ASSURANCE

A. Qualifications:
1. Installer Qualifications:
a. Employ licensed electricians to supervise installation of the work of this Section.
2. Electrical Testing Laboratory (ETL) Qualifications:
a. Use a NETA accredited electrical testing laboratory, or approved equal, that is accredited according to ANSI/NETA ETT for the region in which the Contract work is performed.
b. Submit the electrical testing laboratory's qualifications to the Engineer for approval.

B. Regulatory Requirements:
1. Conform all work to NFPA 70, the National Electrical Code.

C. Certifications:
1. Provide products that are either listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory (ETL) for the location installed in, and the application intended, unless products meeting the requirements of these testing laboratories are not available or unless standards do not exist for the products.

1.05 MAINTENANCE

A. Extra Materials:
1. Provide one set of spare fuses for each point of use including all of the ampere sizes indicated for the location.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Use of Trade Names:
1. The use of trade names within the Contract Documents is intended to establish the basis of design and to illustrate the constructability and level of quality required.
2. The use of trade names is not intended to exclude other manufacturers whose products are equivalent to those named, subject to compliance with Contract requirements.

2.02 MANUFACTURED UNITS

A. Enclosed Disconnect Switches:
   1. Provide enclosed disconnect switches that meet the requirements of NEMA KS l and UL 98, and that are as shown on the Contract Drawings.
      a. Types:
         1) Heavy duty fusible type.
            a) Provide positive pressure fuse clips.
            b) Provide fuses as specified
         2) Heavy duty non-fusible type.
      b. Provide enclosed disconnect switches rated for the horsepower, voltage, and amperage as indicated on the Contract Drawings.
      c. Provide enclosed disconnect switches with the number of poles and of the type indicated on the Contract Drawings.
   2. Enclosure:
      a. Provide enclosures consisting of a box and cover conforming to the requirements of NEMA 250 and of the type indicated or scheduled on the Contract Drawings.
         1) If not otherwise specified, provide enclosures conforming to the requirements of NEMA 250, type 1.
      b. Material:
         1) Construct enclosures of code gauge sheet steel per the requirements of UL 98.
      c. Finish:
         1) Apply a rust-inhibiting phosphate coating to the enclosure’s sheet steel, and then finish the enclosure in gray baked enamel.
      d. Provide a permanent label with the manufacturer's switch type, catalog number, and horsepower rating on the enclosure.
   3. Switch Mechanism:
      a. Provide a quick-make, quick-break operating handle and switch mechanism integral to the box or body, not the cover.
         1) Provide dead front construction with permanent arc suppressors and dual cover interlocks to prevent an unauthorized opening of the switch enclosure when the switch is in the ON position.
         2) Provide the means to positively padlock the switch in the OFF position.
      b. Provide a switch designed so that the switch blades are visible in the OFF position when door is open.
      c. Provide UL-listed switch lugs for front removable copper cables.
      d. Electroplate the switch’s current carrying parts to provide resistance to corrosion.
   4. Acceptable Manufacturers:
      a. Square D Company
      b. Eaton Electric
      c. ABB
      d. Siemens Industry for LV Power Distribution

e. Or Approved Equal

B. Fuses:
1. Provide current limiting type fuses rated for the voltage and amperage as indicated on the Contract Drawings for those low-voltage switches requiring fuses.
a. For non-motor loads, provide UL Class RK1 single element, fast-acting type fuses.
b. For motor, welder, and transformer loads, provide UL Class RK5 dual element, time-delay type fuses.
2. Acceptable Manufacturers:
a. Cooper Bussman
1) UL Class RK1: Limitron®.
2) UL Class RK5: Fusetron®.
b. Gould-Shawmut.
c. Or Approved Equal.

2.03 SOURCE QUALITY CONTROL

A. Testing Agency/Quality Verification:
1. Perform the standard low-voltage enclosed switch factory tests specified in NEMA KS l and UL 98.
2. Submit evidence of testing agency/quality verification, listing, and labeling for each product with the submitted product data either by providing a printed mark on the data or by attaching a separate listing card.
a. For items without such evidence, provide a written statement from the product manufacturer that indicates why it does not have quality assurance verification.
b. Such statements are subject to the approval of the Engineer.

PART 3 EXECUTION

3.01 INSTALLERS

A. Install the work of this Section only under the supervision of licensed electricians.

3.02 PREPARATION

A. Provide a prime and finish coat of paint for painted surfaces that will be covered by items provided under this Section.

B. Prior to painting operations, mask all nameplates, plastic parts, push buttons, operating shafts, and other items not to be painted.

C. Ensure that all indoor areas to receive the items provided under this Section are enclosed from the weather.

3.03 INSTALLATION

A. Install disconnect switches in accordance with the switch manufacturer's instructions.
   1. Mount enclosures on 1/4-inch (6mm) spacers or U-channel supports to provide a space between enclosures and mounting surfaces.
      a. Provide supports as specified in Section 26 05 28, Hangers and Supports.
   2. Set the top of enclosures 6'-6" above the finished floor or grade unless otherwise indicated or specified.

B. Install the switch's conduit and wiring:
   1. Punch holes in the disconnect switch enclosures for conduit entries
      a. Connect conduit to disconnect switch enclosures with water-tight hubs except as follows:
         1) In dry locations, either the watertight hubs or two locknuts and bushings may be used to connect conduits to the disconnect switch enclosure.
         2) In damp locations, either the watertight hubs or a sealing locknut, interior locknut, and grounding bushing may be used on the bottom of the enclosures.
      b. In wet areas, install a conduit drain-fitting in a hole punched in the bottom of the enclosure, and install a conduit breather fitting in a hole punched in the top of the enclosure.
   2. Remove or protect components installed in the interior of enclosures during wire pulling.
   3. Use lugs provided by or approved by the disconnect switch manufacturer to connect wiring to the disconnect switch's line and load terminals in conformance with Section 26 05 19, Low-Voltage Wire, Cable, and Accessories.

C. Identify low-voltage enclosed switches in accordance with Section 26 05 53, Electrical Identification.

3.04 FIELD QUALITY CONTROL

A. Site Testing:
   1. Prior to energizing the low-voltage enclosed switches:
      a. Perform insulation testing and ensure that all load-side wiring is clear of shorts in accordance with the requirements of Section 26 05 63, Electrical Testing.
   2. Final testing after energizing the circuit breakers:
      a. Perform the thermographic test in conformity with Section26 05 63, Electrical Testing, and record the circuit parameters.

3.05 PROTECTION

A. Protect the items provided under this Section during the performance of work provided under other Sections, especially during welding and cutting operations.

B. Protect the low-voltage enclosed switches against overloads, short-circuits, and improper operation.
   1. Pad-lock the low-voltage enclosed switches in the off position when work is being done on downstream circuits.

END OF SECTION

SECTION 26 50 00

LIGHTING

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Requirements for general and emergency egress lighting equipment, components, and related installation.

B. Related Sections:
   1. Division 01 Sections, as Applicable
   2. Section 26 05 26 - Grounding and Bonding.
   3. Section 26 05 28 - Hangers and Supports for Electrical Systems.
   4. Section 26 05 63 – Acceptance Testing of Electrical Systems.
   5. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.
   6. Section 26 05 33.13 – Conduits for Electrical Systems.
   7. Section 26 27 26 - Wiring Devices.

1.02 REFERENCES

A. The Aluminum Association, Inc. (AA):
   1. DAF-45, Designation System for Aluminum Finishes.

B. Federal Communications Commission (FCC)
   1. FCC 47 CFR Part 15, Federal Code of Regulation (CFR) Testing Standard for Electronic Equipment

C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   1. IEEE C62.41; Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits.

D. Illuminating Society of North America (IESNA)
   1. IESNA LM-79, Electrical and Photometric Measurements of Solid-State Lighting Products
   2. IESNA LM-80, Approved Method for Measuring Lumen Maintenance of LED Lighting Sources
   3. IESNA TM-15, Luminaire Classification System for Outdoor Luminaires.

E. National Electrical Manufacturers Association (NEMA):
   1. NEMA 250, Enclosures for Electrical Equipment.
   2. NEMA SSL 3, High Power White LED Binning for General Illumination

F. National Fire Protection Association (NFPA):
   1. NFPA 70, National Electrical Code (NEC).

G. Underwriter's Laboratories, Inc. (UL):
   1. UL 924, Standard for Safety of Emergency Lighting and Power Equipment.
   2. UL 1598, Standard for Safety of Luminaires.
   3. UL 1994, Standard for Safety of Low Level Path marking and Lighting Systems
   4. UL 2108, Standard of Safety of Low Voltage Lighting Systems.

1.03 DEFINITIONS

A. LED – An acronym for "Light-Emitting Diode" used to indicate a semiconductor light source.

1.04 DESIGN REQUIREMENTS

A. Design Criteria:
   1. The Lighting Fixture Schedule on the Contract Drawings constitutes the basis of the lighting design for this Contract, but may not indicate the special design details required.
      a. The Lighting Fixture Schedule includes the lighting fixture descriptions, fixture manufacturers, and corresponding model numbers.
      b. The lighting fixtures as scheduled meet the requirements of the lighting design for this Contract with respect to the visible style and lenses desired.
   2. Provide lighting fixtures meeting the requirements of the basis of the lighting design for this Contract, and which have the special details specified in this Section.
      a. Submit Shop Drawings and manufacturer's installation instructions to show details of assemblies and sub-assemblies, and specially-fabricated supporting and fastening devices.
      b. Submit bills of material for the fixtures and their appurtenances.
         1) Reference the bills of material to the Shop Drawings.
         2) Provide bills of material consisting of itemized lists of the parts required.
         3) Identify each part with a part number and/or manufacturer number.
      c. Provide fixtures for exterior installation that are designed to be completely waterproof.
      d. Provide luminaire brackets designed to be compatible with configuration of the luminaire.

B. Prior to providing light fixtures substituted for the fixtures identified in the Lighting Fixture Schedule on the Contract Drawings, submit the following information to obtain the Engineer's approval to substitute the fixtures:
   1. The manufacturer's catalog cuts indicating the type, design, dimensions, mounting arrangement, and other industry standard lighting fixture information.
      a. Describe the lighting fixtures, exit signs, emergency battery units, and appurtenances.
   2. Manufacturer's photometric data, distribution curves, isolux charts, glare factor data, and coefficient of utilization.

3. Complete photometric data for the fixture, including optical performance, completed by an independent testing laboratory developed according to the standards of the Illuminating Engineering Society of North America as follows:
    a. For direct, direct/indirect and indirect lights used for general illumination:
        1) Coefficients of utilization.
        2) Candlepower data, presented graphically and numerically, in 5 degree increments (5 degree, 10 degree, 15 degree, etc.). Data developed for up and down quadrants of normal, parallel, and at 22-1/2 degree, 45 degree, 67-1/2 degree planes to lamp(s). If light output is asymmetric, provide additional planes as required to complete report.
        3) Zonal lumens stated numerically in 10 degree increments (5 degree, 15 degree, etc.) as above.
        4) Average luminaire luminance calculated in the lengthwise, crosswise, and 45 degree vertical planes.
    b. For exterior roadway, area, or floodlighting luminaires, photometric data shall include isocandela charts, coefficient of utilization, IES roadway distribution classification (where applicable), and isofootcandle plots for the specific mounting heights, lamps, and conditions of the project.
4. Point-by-point lighting calculations showing the uniformity of light on the horizontal work plane in areas where substitutions are proposed. The substituted fixture shall be equivalent to the named fixture, including lighting level and energy usage.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements:
    a. The execution of work of this Section must satisfy the applicable requirements of the latest edition of NFPA 70 (NEC), the National Occupational Safety and Health Act as embodied in 29 CFR 1910 and 29 CFR 1926, and regulations of local jurisdictional authorities.
    2. Comply with the requirements of the Energy Policy Act (EPACT) of 2005 and the applicable version of the International Energy Conservation Code.

B. Certifications:
    1. All products must be Underwriters' Laboratories (UL) listed; and each fixture, Emergency Battery Unit, and exit sign must bear the UL label.
        a. The UL standards appropriate for the products specified are listed in Paragraph 1.02.E.
        b. Alternatively, Listing by an OSHA Nationally Recognized Testing Laboratory (NRTL) to the relevant UL standards is permitted.
    2. Fixtures that are to be installed in areas subject to the weather must be UL listed as "Enclosed and gasketed suitable for wet locations".

1.06 SUBMITTALS

A. Submit the following information for approval in accordance with the requirements of Section 01 33 00, Submittal Procedures:
   1. Product Data:
      a. Manufacturer's catalog cuts.
         1) Lighting fixtures catalog cuts
      b. Manufacturer's photometric data, distribution curves, isolux charts, glare factor data, and coefficients of utilization for each lighting fixture type.
   2. Shop Drawings:
      a. Shop Drawings.
      b. Bills of material.
   3. Quality Assurance/Quality Control Submittals:
      a. Design Data:
         1) Calculations demonstrating that substituted fixtures are equivalent to the named fixtures.
      b. Certificates:
         1) Proof that equipment furnished has the required Underwriters' Laboratories (UL) listing.
      c. Manufacturer's Instructions:
         1) Manufacturer's installation instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Conduit and Raceway:
   1. Provide electrical conduit and raceway in accordance with the requirements of Section 26 05 33.13 as indicated for the application per NFPA 70.

B. Control Devices:
   1. Provide electrical lighting control devices in accordance with the requirements of Section 26 27 26.

C. Fixture Support Devices and Fasteners:
   1. In addition to the supporting devices and fasteners specified in Section 26 05 28, provide suspension accessories, canopies, casing, sockets, holders, reflectors, plaster frames, recessing boxes, and similar items required to support the lighting equipment and luminaries as specified or indicated.

D. Wire and Cable:
   1. Provide electrical wire and cable in accordance with the requirements of Section 26 05 19.

2.02 MANUFACTURED UNITS

A. Light Fixtures:
   1. Provide those fixtures indicated on the Lighting Fixture Schedule on the Contract Drawings or approved substitutions.
      a. The manufacturers' fixture descriptions and corresponding fixture model numbers are also listed in the Lighting Fixture Schedule.
      b. Additional manufacturers who can provide products comparable to those provided by the manufacturers listed and whose products the Contractor proposes to use for this Contract must first be submitted to and receive the approval of the Engineer prior to being substituted for the listed manufacturers.
   2. Fixture Grounding Device and Conductor:
      a. Provide the housing of each fixture with a separate, factory-installed grounding device and ground conductor.
   3. Exterior Fixtures:
      a. Factory-equip fixtures intended for exterior installation with waterproof gaskets and anodized aluminum frames unless indicated otherwise on the Contract Drawings.
         1) Provide outlet boxes, neoprene gaskets, and stainless steel hardware to render the exterior fixture installation waterproof.
      b. Finish:
         1) Provide fixtures for exterior installation with a finish free of scratches and other surface blemishes.
      c. Brackets:
         1) Provide brackets of the type and style indicated or scheduled on the Contract Drawings and color matched to the light fixture.

B. LED Lighting Fixtures (excluding LED exit signs)
   1. Color temperature of any substituted fixture shall be within 10% of the specified value shown on the drawings.
   2. Power consumption of any substituted fixture shall not exceed the specified value shown on the drawings by more than 10%. If a substituted fixture is submitted and approved at an increased wattage 9within 10% of the specified wattage), any power system modifications necessary to accommodate the fixtures will be the responsibility of the contractor (i.e. increased wire sizes, increased circuit breaker size, additional circuits/breakers, etc.)
   3. LED Lumen Efficacy (Lumens/Watt) of a substituted fixture shall not be less than the specified fixture by more than 10%.
   4. Characteristics of substituted fixtures shall have the same features as the specified LED fixtures (i.e. redundant drivers, driver protection, etc.) whether specifically noted on the lighting fixture schedule or not.

5. Drivers shall not exceed 350mA unless specifically noted otherwise on the lighting fixture schedule. Drivers shall have a Class A sound rating.
6. LED Light fixtures shall have a minimum expected life of 50,000 hours. The aforementioned life rating must be conducted with a 40 degrees calcium ambient temperature.
7. Power Factor: The LED fixture shall have a power factor of 0.90 or greater.
8. Total Harmonic Distortion induced into the AC power line by the luminaire shall not exceed 20 percent.
9. Surge Suppression: The LED fixture on-board circuitry shall include surge protective devices to withstand high repetition noise transients as a result of utility line switching, nearby lightning strikes, and other interference. The SPD shall protect the luminaire from damage and failure for common mode transient peak voltages up to 10 kV (minimum) and transient peak currents up to 5 kA (minimum). SPD shall conform to UL 1449 depending of the components used in the design. SPD performance shall be tested per the procedures in ANSI/IEEE C62.41-1992 (or current edition) for category A (standard). The SPD shall fail in such a way as the Luminaire will no longer operate. The SPD shall be field replaceable.
10. Operational Performance: the LED circuitry shall prevent visible flicker.
11. Thermal Management: The thermal management (of the heat generated by the LED's) shall be of sufficient capacity to assure the proper operation of the luminaire over the expected useful life. Thermal management shall be by passive design – the use of fans or other mechanical devised is not allowed.

C. Boxes, Gaskets, Hardware, and Support Devices:
   1. Provide outlet boxes, neoprene gaskets, and stainless steel hardware to render the installation of the lighting waterproof.
      a. Provide waterproof splice kits where required as specified in Section .
   2. Supply pendant stems, special mounting supports and hardware, and miscellaneous materials and incidentals required to install the lighting and emergency battery unit products in place.
   3. Provide neoprene spacers for maintaining clearance between lighting and emergency battery unit products and concrete, mortar, and other masonry surfaces.

PART 3 EXECUTION

3.01 EXAMINATION

A. Prior to ordering flush mounted or lay-in type lighting fixtures, verify their locations and clearances, and coordinate with other construction work to verify that the fixtures will fit without interferences.
   1. The Engineer assumes no responsibility for clearance, dimensions, tolerances, or exact hanging frame dimensions.

B. Prior to beginning installation of the lighting fixtures and accessories, verify that all other work affecting the installation of the lighting fixtures and accessories is complete to the extent that the light fixtures may be installed over substrates or incorporated into integrated systems without adversely affecting the lighting or other construction.

3.02 INSTALLATION

A. Assemble lighting fixtures if required; and install and wire the lighting fixtures, supports, brackets, and accessories at the locations and mounting heights indicated on the Contract Drawings.
   1. Wire the lighting fixtures and accessories as specified in Section 26 05 19.
   2. Ground the lighting fixtures in accordance with the requirements of Article 410 of NFPA 70 (NEC) and Section 26 05 26.
      a. Use the fixture grounding device to connect a separate grounding conductor in compliance with requirements specified in Section 26 05 26.
   3. Install all photoelectric controls facing north for proper operation.

B. Exposed Fixture Installation:
   1. Install surface mounted and exposed fixtures as indicated on the Contract Drawings.
      a. Hang suspended fixtures plumb, with continuous rows of fixtures in alignment.
      b. Mount suspended fixtures in each room or area at the same height regardless of varying clear height conditions unless otherwise indicated on the Contract Drawings.
      c. Install surface mounted fixtures tight up against the substrate to eliminate gaps except where NFPA 70 (NEC) or local code restrictions require a separation between the fixtures and substrate.
   2. Exit Fixture Installation:
      a. Install exit fixtures for doors directly over the doorways as indicated on the Contract Drawings
      b. Center the fixtures over the doorways, and install the fixtures to clear the door and associated hardware.

3.03 INTERFACE WITH OTHER WORK

A. Verify the locations and clearances of other installed or proposed work, and coordinate lighting fixture installations accordingly.

B. Coordinate the installation of lighting fixtures with all building systems and components to avoid any installation conflicts.

3.04 FIELD QUALITY CONTROL

A. Inspect, test, and certify lighting and the associated electrical distribution system and equipment in accordance with the requirements of Section 26 05 63.

3.05 CLEANING

A. Clean new lighting fixtures by following the cleaning procedures as recommended by the fixture manufacturer:
   1. Use only those products for cleaning as recommended in the fixture manufacturer's literature.

END OF SECTION

SECTION 27 00 00

COMMUNICATIONS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: The work specified in this Section consists of materials for furnishing, installing and connecting Cat. 6 cable.

B. Related Section:
1. Section 26 05 00 – Common Work Results for Electrical
2. Section 26 05 26 – Grounding and Bonding for Electrical Systems
3. Section 26 05 33.13 – Conduits for Electrical Systems

1.02 REFERENCES

A. American National Standards Institute (ANSI)/Telecommunications Industry Association (TIA)/Electronics Industry Alliance (EIA):

1.	ANSI/TIA/EIA-568-B.1	Commercial Building Telecommunications Cabling Standard – Part 1: General Requirements.
2.	ANSI/TIA/EIA-568-B.2	Commercial Building Telecommunications Cabling Standard – Part 2: Balanced Twisted Pair Cabling Components.
3.	ANSI/TIA/EIA-569-A	Commercial Building Standard for Telecommunications Pathways and Spaces.
4.	ANSI/TIA/EIA-606	Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
5.	ANSI/TIA/EIA-607	Commercial Building Grounding and Bonding Requirements for Telecommunications.

B. Institute of Electrical and Electronic Engineers (IEEE):

1.	IEEE 802.3ab	Physical Layer Parameters and Specifications for 1000 Mb/s Operation over 4 pair of Category 5 Balanced Copper Cabling, Type 1000BASE-T.

C. Insulated Cable Engineers Association (ICEA):

1.	ANSI/ICEA S-80-576	Communication Wire and Cable for Wiring of Premises.

D. National Electrical Manufacturers Association (NEMA):

1.	NEMA WC 63.1	Telecommunications Cables

E. Underwriters Laboratories (UL):

1.	UL 444	Communications Cables.

2. UL 467 Grounding and Bonding Equipment.
3. UL 1863 UL Standard for Safety for Communications-Circuit Accessories.

F. National Fire Protection Association (NFPA):
1. NFPA 70 National Electrical Code (NEC).

1.03 GENERAL REQUIREMENTS

A. Provide Cat. 6 cabling (terminated and tested) for the bus wash equipment installation.

1.04 SUBMITTALS

A. Testing Agency/Quality Verification: Provide with all product data evidence of testing agency/quality verification, listing, and labeling either by printed mark on the data or by a separate listing card. Provide from product manufacturers a written statement indicating why an item does not have a quality assurance verification. Such statements are subject to the approval of the Engineer.

B. Product Data and Catalog Cuts: Submit product data for all products provided. Indicate clearly the usage of each product.

C. Shop Drawings:
1. Cat. 6 Cable

D. Installer Qualifications: Prior to installation, submit data of installer's experience and qualifications. Include names and locations of two projects successfully completed using copper cabling systems. Include specific experience in installing and testing of Category 6 cabling systems.

E. Test Plan: Provide a complete and detailed test plan for the telecommunications cabling system including a complete list of test equipment for the UTP components and accessories. Include procedures for certification, validation, and testing.

F. Submit Operation and Maintenance (O & M) Manuals which shall include detailed parts lists, lists of recommended spare parts, circuit diagrams, maintenance procedures, and operating instructions.

1.05 QUALITY ASSURANCE

A. Provide products that are listed and labeled by Underwriters Laboratory, approved by Factory Mutual, or certified as meeting the standards of UL by the Electrical Testing Laboratory unless products meeting the requirements of these testing laboratories are not readily available or unless standards do not exist for the products. Provide products that are listed and labeled or approved as stated above for the location installed in and listed and labeled or approved as indicated and specified for the applications the items are intended for.

B. Provide products that have been third party performance tested by a Nationally Recognized Independent Testing Laboratory. Test results shall be provided upon request of the Engineer.

C. Manufacturer Qualifications: Firm specializing in installing work of this Section with minimum five years documented experience in construction of similar equipment.

D. Conform all work to NFPA 70, National Electrical Code.

E. Installer Qualifications: Firm specializing in installing work of this Section with minimum three years documented experience.

F. Install work under supervision of skilled licensed electricians.

PART 2 PRODUCTS

2.01 CONNECTORS

A. Category 6 Cable:
   1. Comply with NFPA 70, NEMA WC 63.1, ANSI/ICEA S-80-576 and performance characteristics in ANSI/TIA/EIA-568-B.
   2. UTP (unshielded twisted pair), 100 ohm. Provide four each individually twisted pair, 24 AWG conductors, NFPA 70 CMG rated, with a blue PVC jacket. NFPA 70 type CMP or CMR may be substituted for type CMG. Individual pairs shall be constructed to contain a minimum two twists per foot per each pair. Overall diameter of four pair cable shall not exceed 0.25 inches (6.32 mm). Ultimate breaking strength shall be minimum 90 pounds (40.82 kg). Four pair cable shall withstand a bend radius of one inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking. Conductors shall be color coded and polarized in accordance with ANSI/TIA/EIA-568-B. Jacket sequentially marked at two-foot intervals. Shall conform to Category 6 requirements and be 1000BASE-T compliant.
   3. Acceptable Manufacturers:
      a. Belden.
      b. CommScope.
      c. General Cable.
      d. Hubbell Premise Wiring.
      e. HCM (Hitachi Cable Manchester, NH)
      f. Or Approved Equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Cable Installation in Conduits and Ducts: During the installation of cables in conduits and ducts, the cable manufacturer’s recommended pulling tension shall not be

exceeded. A suitable lubricating medium, harmless to the cable jacket, shall be used when pulling cables into conduits, pipes or duct banks. No oil or grease substances not specifically manufactured for cable installation will be permitted for such use on this project.

B. Strain Relief: Provide sufficient strain relief (slack) in all cables, cable conductors, and wiring to avoid stress on all cables, wires, and wiring connections.

C. Bends: Cables shall not be bent to a radius less than ten (10) times the diameter of the cable, or less than the manufacturer's recommended minimum bending radius, during installation or as finally installed.

D. Continuous Cable Sections: All cable runs shall be continuous without splices between cable terminating locations.

E. Conduit/Cable Entrances to Facilities: All conduit and cable entrance openings into equipment rooms and huts shall be sealed with a pliable sealing compound after the cable is in place. Sealing compounds for rooms, huts, walls, or other partitions shall be fire retardant per ASTM E 814. Sealing compound shall be used to seal the area around the cable where the cable emerges from the end of a conduit, pipe, or ductbank. All spare conduits shall be sealed or plugged in an approved manner.

F. Fire retardant pliable sealing compound shall be an intumescent firestop putty, reusable and repenetrable, conforming to ASTM E 814 and UL 1479, Nelson FSP Firestop Putty, or Approved Equal.

G. Protection of Cables: Provide appropriate special protection for cables in areas where the cables are unavoidably exposed to hazardous conditions, such as sharp corners on equipment. Cables damaged due to neglect by the Contractor, during installation, shall be replaced by the Contractor at no additional cost to the Owner.

H. Cable Continuity and Integrity: All cables shall be continuous and without splices between the specified termination locations. The cable termination points shall be located within communication interface cabinets, equipment enclosures, splice cases, and equipment termination boxes as shown on the Drawings and as described in the Specifications.

I. Cable Shield Continuity and Integrity: The shield of each section of communication cable shall be electrically continuous for the entire cable length.

J. Cable and Wiring Identification: All cables shall be terminated in standard order, according to the EIA/TIA and ICEA color codes. Individual cables shall be identified at each cable termination with self-adhesive labels. All spare pairs in each cable shall be terminated and identified.

K. All cables shall be installed in raceways as specified in Section 26 05 33.13.

L. Conduits shall be restricted to no more than two 90-degree bends or equivalent without a pull box.

M. Maintain minimum bending radius of changes in direction as follows:
   1. 10 times diameter of 4" and larger conduits.
   2. 6 times diameter of smaller conduits.

N. Avoid bends in conduits from pull boxes.

O. Except as noted hereinafter for telecommunications cabling and pathways with copper media, keep conduit minimum 6 inches away from parallel runs of electrical power equipment, flues, steam, and hot water pipes.

P. Telecommunications cabling and pathways with copper media shall be installed in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications equipment.
   1. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling.
   2. Pathways shall be installed in accordance with the following minimum clearance distances of 4 feet (1.2 meters) from motors, generators, frequency converters, transformers, x-ray equipment or uninterruptible power system, 12 inches (300 mm) from power conduits and cable systems, 5 inches from fluorescent or high frequency lighting system fixtures.

Q. Install cabling and pathway system as detailed in ANSI/TIA/EIA-568-B and -569-A. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not untwist Category 6 UTP cables more than one half inch (12 mm) from the point of termination to maintain cable geometry. Do not exceed manufacturers' cable pull tensions for copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or crush cables with staples. For UTP cable bend radii shall not be less than four times the cable diameter.

R. All communications cables for the inside plant shall be terminated. Terminate all copper cabling with jacks.

S. Terminate UTP cable in accordance with ANSl/TIA/EIA-568-B and wiring configuration as specified.

T. Provide identification and labeling of communications cables, outlets and equipment per ANSI/TIA/EIA-606.
   1. All cables shall be labeled at least at each end of each cable section, using cable tags or labels. Inside plant cables shall be labeled using self adhesive waterproof labels; outside plant cables shall be labeled using approved waterproof cable tags.

3.02 FIELD QUALITY CONTROL

A. Perform telecommunications cabling inspection, verification, and performance tests in accordance with ANSI/TIA/EIA-568-B.

B. Inspection: Visually inspect cabling jacket materials for UL or third party certification markings. Visually inspect UTP jacket materials for UL or third party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for tip and ring pin assignments, and inspect cabling connections to confirm compliance with ANSI/TIA/EIA-568-B. Visually confirm Category 6 marking of connectors.

C. Perform testing after cables are terminated, but not cross connected.

D. Verification Tests:
   1. UTP backbone copper cabling shall be tested for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after terminated but not cross connected. Perform 1MHz to 100MHz scan attenuation test for Category 6 systems installations.

E. Performance Tests:
   1. Category 6: Perform UTP permanent link tests in accordance with ANSI/TIA/EIA-568-B. Tests shall include wire map, length, attenuation, NEXT, Power Sum NEXT, ELFEXT, Power Sum ELFEXT, return loss, propagation delay and delay skew. Each and every link shall be tested and shall pass the requirements of ANSI/TIA/EIA-568-B for Category 6. Any failing link shall be diagnosed and corrected. The corrective action shall be followed by a new test to prove that the corrected link meets the performance requirements. The final and passing result of the tests for all links shall be provided in the test results documentation.

END OF SECTION

SECTION 31 20 00

EARTHWORK

PART 1 GENERAL

1.01 SECTION INCLUDES

A. The work specified in this section consists of excavation for excavation and placement of compacted fill and backfill for structures, subgrade and foundation preparation, and subsurface extraction of miscellaneous structures and facilities indicated to be removed.
   1. Earthwork for this project is Unclassified. No additional payment will be made to any Contractor should rock or other underground anomalies be encountered during earthwork or trenching operations.

1.02 RELATED WORK

A. Section 03 30 00: Cast-in-place Concrete.

B. Section 31 23 33: Trenching and Backfilling

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM):
   1. ASTM C 131; Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   2. ASTM C 136; Test Method for sieve Analysis of Fine and Coarse Aggregates.
   3. ASTM C 535; Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   4. ASTM D 422; Test Method for Particle-size Analysis of Soils.
   5. ASTM D 427; Test Method for Shrinkage Factors of Soils by the Mercury Method.
   6. ASTM D 653; Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
   7. ASTM D 698; Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu.ft.).
   8. ASTM D 1140; Test Method for Amount of Material in Soils Finer than the No. 200 (75 Micrometer) Sieve.
   9. ASTM D 1557; Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu.ft.).
   10. ASTM D 2216; Test Method for Laboratory Determination of Water (moisture) Content of Soil and Rock.
   11. ASTM D 2487; Classification of Soils for Engineering Purposes (United Soil Classification System).

12. ASTM D 2922; Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
13. ASTM D 3017; Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
14. ASTM D 4253; Test Methods for Maximum Index Density of Soils Using a Vibratory Table.
15. ASTM D 4254; Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
16. ASTM D 4318; Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

B. Occupational Safety and Health Administration (OSHA).

C. Commonwealth of Pennsylvania Department of Transportation (PennDOT)
1. Publication 408, Specifications, as supplemented (PDT Pub. 408).
   a. Section 220 Flowable Backfill.
   b. Section 703.2 Coarse Aggregate.
   c. Section 704 Cement Concrete.
   d. Section 735 Geotextile.
2. Publication 19 Pennsylvania Test Methods (PTMs).
   a. PTM No. 604.

1.04 DEFINITIONS

A. Earthwork Terminology: Terms used in this Section and not defined herein shall be interpreted in accordance with the definitions given in ASTM D 653.

B. Approved Material: Material which meets specified requirements for use as embankment, fill or backfill.

C. Backfill: Soil or soil-rock material used to backfill excavations and to backfill excavated spaces around foundation walls, building walls, retaining walls, and abutments.

D. Borrow: Soil material used in embankment or other construction which is excavated from any location other than required onsite excavations.

E. Excavation is the removing of all materials encountered within the indicated or specified limits, regardless of the nature of the material encountered and the method by which removed, and further defined in Part 1 Article, "Classification of Earthwork," below.

F. Excess Excavation: Material excavated beyond or below cross section shown, as well as unavoidable overbreakage in rock.

G. Imported Material: Soil or granular material which is hauled in from off-site areas.

H. Optimum Moisture Content: The water content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort.

I. Relative Compaction: The ratio, expressed as a percentage, of the in-place dry density of fill material as compacted in the field to the maximum dry density of the same material as determined by laboratory test ASTM D 1557, Method D.

J. Relative Density: Refer to ASTM D 4253 and ASTM D 4254.

K. Soil Classification: Soil classification is based on the Unified Soil Classification system given in ASTM D 2487. Group symbols, when used, conform with the symbols of ASTM D 2487.

L. Subgrade: Subgrade is the lowest elevation of excavation and the highest elevation of embankment required to accommodate the indicated construction.

M. Unsuitable Material: Excavated material or material below the natural ground surface in embankment areas or below subgrade elevation in excavated areas, which is unsuitable for its planned use as determined by the Owner. Unsuitable material is further defined as material determined to be:
   1. Of such unstable nature as to be incapable of being compacted to specified density using ordinary methods at optimum moisture content; or
   2. Too wet to be properly compacted and circumstances prevent suitable in-place drying prior to incorporation into the work; or
   3. Otherwise unsuitable for the planned use.
   4. The presence of excessive moisture in a material is not, by itself, sufficient cause for determining that the material is unsuitable. The existence of unsuitable material may be indicated in the Contract Documents.

1.05 QUALITY ASSURANCE

A. Inspections and Tests: The Contractor shall provide quality control inspections and tests as specified under Part 3 Article, "Field Quality Control," to assure compliance with specified requirements.

B. Laboratory and Geotechnical Services: Engage the services of an approved independent soils testing laboratory to perform the above-specified inspections and tests. Foundation and subgrade preparation and the placement and compaction of fills shall be performed under the general supervision of a (state) registered geotechnical engineer.

C. If required, Special Inspections will be the responsibility of the owner. Coordinate access to any required Special Inspections.

D. Tolerances:
   1. Construct finished subgrades to plus or minus 1/2 inch of the elevations indicated.

2. Maintain the moisture content of fill material as it is being placed within plus or minus two percent of the optimum moisture content of the material as determined by the laboratory tests herein specified.

1.06 SUBMITTALS

A. In accordance with Division 1 specifications, submit the following:
   1. A schedule of all tests specified to be performed by the Contractor.
   2. Three (3) copies each of test reports of all tests specified to be performed.
   3. Samples: Furnish and deliver samples of fill and backfill materials as selected by the Owner for testing and analysis.
   4. Permits for disposal of excavated material:
      a. Obtain written permits and releases from owners of property where material will be deposited.
      b. Submit copies of each permit and release from each property owner absolving the Government from responsibility in connection with such disposal.
   5. Delivery Tickets: Submit a delivery ticket with each load of imported borrow material delivered to the site, stating the type of fill material and the quantity.
   6. Flowable Fill: Submit for approval the following:
      a. Provide a mix design that conforms to the requirements for flowable fill presented in PENNDOT Publication 408, Section 220.
      b. Results of slump tests conducted in accordance with ASTM C143.
      c. Results of compressive strength tests conducted at 28 days in accordance with PTM No. 604.
      d. Results of density tests conducted in accordance with AASHTO T 121.

1.07 CLASSIFICATION OF EARTHWORK

A. Excavation and backfill are classified according to the purpose of the work, as follows:
   1. Structure Excavation and Backfill: The removal of material for the construction of foundations for aerial structures, bridges, buildings, retaining walls, headwalls, and other structures, and other excavation indicated as structure excavation. Structure backfill includes furnishing material, if necessary, and placing and compacting backfill material around structures to the lines and grades indicated.
   2. Ditch Excavation: Includes excavating ditches within the building.

B. Subgrade and foundation preparation includes fine grading and compaction of excavations, moisture-conditioning and compaction of subgrades, and original ground upon which pavement, surfacing, base, subbase, or structures are to be constructed. Subgrade preparation includes the placement and compaction of structural fill material in holes, pits, and other depressions within areas to be paved and landscaped.

C. Structure Excavation: The removal of material for the construction of foundations for aerial structures, bridges, buildings, retaining walls, headwalls and other structures, and other excavation indicated as structure excavation.

D. Structure Backfill: Structure backfill includes furnishing structure fill material for raising grades, and placing and compacting structural fill material around structures to the lines and grades indicated. Structure backfill includes borrow excavation and material when required.

1.08 JOB CONDITIONS

A. Barricade open excavations and post with warning lights those excavations occurring on property adjacent to or within public access. Operate warning lights during hours from dusk to dawn each day and as otherwise required.

B. Use of Explosives:
1. Not allowed in performance of excavation work.

C. Toxic and Combustible Substances:
1. During excavation, provide equipment and carry out such tests as necessary to detect presence of toxic and combustible substances.
2. If the presence of noxious or explosive gas is indicated, immediately discontinue excavation operations and notify the Owner. Do not resume work at this location until the necessary safety measures have been enforced and further tests indicate the absence of noxious and explosive gases.
3. Take action to safeguard persons and property in accordance with rules and regulations of jurisdictional agencies and utility owners.
4. Promptly notify utility owners when problems concerning their facilities become apparent.

D. If a change in location is made at the requirement of the Owner and involves the abandonment of excavation already made, such abandoned excavation, together with the necessary backfill will be classified as Miscellaneous Unclassified Excavation and Backfill.

PART 2 PRODUCTS

2.01 FILL AND BACKFILL MATERIALS

A. General Requirements:
1. Fill and backfill material: Inert, nonexpansive soil, free from organic matter and other deleterious substances, and of such quality that it will compact thoroughly without the presence of voids when watered and rolled. Excavated on-site material will be considered suitable for fil and backfil construction if it is free from organic matter and other deleterious substances and conforms to the requirements specified herein.

2. Excavated material which is suitable for fill and backfill construction shall be conditioned for reuse and properly stockpiled for later filling and backfilling operations. Conditioning shall consist of spreading material in layers not to exceed 8 inches and raking free of debris and rubble. Rocks exceeding 4 inches in largest dimension and deleterious material shall be removed from the site and disposed of as specified herein under Disposal of Surplus Material.
3. Where conditions require the importing of fill or backfill material, the material shall be an inert, nonexpansive soil or soil-rock material free of organic matter and meeting or exceeding the minimum requirements specified herein for the location.
4. Fill and backfill material shall conform to the following minimum requirements, unless otherwise specified:
   a. Liquid Limit (ASTM D 4318): 45 maximum
   b. Plasticity Limit (ASTM D 4318): 25 maximum

B. Specific Requirements:
1. Select Fill: Well- to moderately well-graded soils consisting of sands, silts, and clays, with or without gravel, as excavated, screened, or blended, having the following physical properties and gradation:
   a. Laboratory Dry Density: 100 pcf minimum.
   b. Gradation (ASTM D422):

Sieve Opening	Percent Passing By Weight
1 inch square	100
U.S. No. 4	20 minimum
U.S. No. 10	10 minimum
U.S. No. 200	45 maximum

2. Structural Fill: No. 2A Course Aggregate in accordance with Section 703, PDT Pub. 408.

C. Flowable Backfill Type A or B: conforming to the requirements of PENNDOT Publication 408, Section 220.

2.02 MATERIALS FOR EARTHWORK

A. Fill and Backfill Materials: Where specific fill, backfill, and embankment materials are not indicated on Contract Drawings, conform to the following requirements:
1. Subgrade and Foundation: Structural Fill for a depth of not less than 12 inches. Common Embankment where Structural Fill is not specified.
2. Backfill against Concrete Walls and Waterproofing: Select Fill.
3. Backfill for Abandoned Vaults (including airways, cross adits, and similar voids): Structural Fill.
4. Backfill Under Supporting Walls and Columns and Similar Locations: Structural Fill.
5. Backfill Where Not Otherwise Indicated: Approved Materials.

2.03 SOURCE QUALITY CONTROL

A. Fill and backfill materials proposed to be used in the work shall be tested in the laboratory for compliance with specified requirements as follows:
   1. Moisture-Density Relationship: ASTM D 698.
   2. Moisture Content: ASTM D 2216.
   3. Liquid Limit: ASTM D 4318.
   4. Plastic Limit and Plasticity Index: ASTM D 4318.
   5. Sieve Analysis: ASTM D 422, and ASTM C 136, as applicable.
   6. Percent Passing No. 200 sieve: ASTM D 1140.

B. Where classification of soils is necessary to meet specified requirements, perform laboratory tests in accordance with ASTM D 2487.

2.04 SOURCE OF MATERIALS

A. To the extent that it is available, obtain material from excavation operations. If sufficient suitable materials are not available to meet embankment, fill and backfill requirements, obtain material meeting specified requirements from outside sources at no additional cost to the Owner.
   1. Earth excavation may contain excess moisture in its natural state or may take on excess moisture during handling and stockpiling. Manipulation to dry material to proper moisture content prior to compaction may be necessary. Earth excavation will not be considered as unacceptable backfill material by virtue of its moisture content only.

B. Use only material whose quality, source, and zone of placement in the fill have been approved.

PART 3 EXECUTION

3.01 STAKING AND GRADES

A. Layout the work, establish all necessary markers, benchmarks, grading stakes, and other stakes as required to properly define and construct proposed facilities.

B. Perform surveys prior to, during, and following work as necessary. Surveys shall include:
   1. Initial survey of original ground.
   2. Final surveys when excavations and backfills are completed.

3.02 EXISTING UTILITIES

A. Verify on site the location and depth (elevation) of all existing utilities and services before performing any excavation work. Perform excavation within 2 feet of a utility line by hand.

B. Remove abandoned sewers, piping, and other utilities encountered during excavation and plug the ends.

C. Report immediately to the Owner any active utility lines encountered, which are not indicated in the Contract Documents, and notify utility owners involved. The Owner and utility authorities shall be permitted free access to determine the measures deemed necessary to repair, relocate, or remove the utility.

3.03 EARTHWORK GENERAL REQUIREMENTS

A. On-Site Excavation or Borrow Pits: Do not excavate or remove any material from the project site or right-of-way which is not within the designated excavation, as indicated by the slope and grade lines.

B. Stockpiling of Fill and Backfill Material:
1. Excavate and separately stockpile suitable fill and backfill material. Save sufficient suitable excavated material, if available, for later filling and backfilling.
2. Store materials from required excavations which are suitable for fill, backfill, and embankment as excavated, in stockpiles segregated by type.
3. Establish excavated material stockpiles on site only in locations where they will not interfere with the progress of the work. Off-site stockpiling, if necessary, shall be the responsibility and at the expense of the Contractor.

C. Disposal of Surplus Material:
1. Haul from the site and legally dispose of excess excavated materials and those materials determined to be not suitable for fill or backfill.
2. Location of disposal site and length of haul shall be the Contractor's responsibility.
3. Surplus material may be disposed of within the site as directed by the Owner.

D. Maintenance of Excavations and Slopes:
1. Excavate and remove material outside the limits of excavation which is unstable and constitutes potential slides, and material which comes into excavations for any reason including from the driving of piles.
2. Maintain slopes until final completion and acceptance of the work. Promptly repair slides, slipouts, washouts, settlements, and subsidences which occur for any reason, and refinish the slope or embankment to the indicated lines and grades.

3.04 SUBSURFACE EXTRACTION

A. Remove subsurface facilities and obstructions to the extent indicated.

B. When subsurface facilities are encountered during excavation which interfere with new construction, and such facilities are not indicated, notify the Owner promptly for corrective determination.

3.05 PUMPING AND DRAINAGE

A. At all times during construction of the work and at its completion for final inspection, by the Owner, provide and maintain ample means and suitable equipment, consistent with conditions encountered, to promptly remove and properly dispose of all water entering excavations or other parts of the work.

B. Control surface and subsurface water in excavations at all times until the structures to be built therein are completed and backfilled to approximately final grades.

C. Dispose of water in a suitable manner approved by the Owner so as to avoid damage to adjacent property, existing structures, and all work under construction. Do not pump drainage water onto the streets without the written permission in advance from the Owner.

D. Provide and maintain, settling basins and sumps for catching and holding settleable matter. These shall be frequently cleaned and maintained. Wherever water containing mud, clay, sand or other material in suspension, is pumped from the excavations, make suitable provision to insure that the flow will be unobstructed. Take precautions to avoid pumping water through freshly placed concrete.

E. At no time shall the uplift pressure on any structure exceed 80 percent of the downward pressure produced by the weight of the structure and any backfill in place. The Contractor shall submit his proposed methods of controlling uplift pressure to the Owner for approval prior to the start of excavation.

3.06 EXCAVATION

A. General Excavation Requirements:
   1. Perform excavating as indicated and required for concrete footings and foundations. Provide shoring, bracing, underpinning, cribbing, pumping, and planking as required.
   2. The bottoms of excavations shall be level, firm, undisturbed earth, clean and free from loose material, debris, and foreign matter.
   3. Excavate to the lines and grades indicated on the Contract Drawings.
   4. Support and maintain excavations so that sides are stable and will not move. Excavations may be maintained by sloping cut faces where space permits.
      a. Where the sides of excavations are sloped, angle of slopes shall be as approved by the Owner but shall not be steeper than allowed by the Title 29 Code of Federal Regulations, Part 1926, Safety and Health Regulations for Construction (OSHA).
      b. Maintain sides and slopes of excavations in safe condition until backfilling is completed.
      c. Where the Contractor elects to slope the sides of excavations, backfill of the over-excavated areas shall be made in the same manner specified for the

adjacent excavated area. All additional backfill required shall be at no additional cost to the Owner.

5. Limits of excavations shall allow for adequate working space for installing forms, wall waterproofing, and as required for safety of personnel. Cut excavations in solid rock accurately to the neat lines indicated on Contract Drawings, or to the width of the duct bank or concrete encasement.
6. Remove unstable bottom material. Remove large stones, debris, and incompressible soils from common excavation bottoms to a minimum depth of 12 inches. Where required to excavate to rock, it shall be understood to mean sound bedrock. Remove friable and unsound material.
7. Except as otherwise indicated, preserve the material below and beyond the lines of excavations. Where excavation is carried below the indicated grade, backfill to the indicated grade as herein specified.
8. Excavation and its restoration, for convenience of the Contractor, shall be at no additional expense to the Owner.
9. Place excavated material at sufficient distance from edge of excavation so as not to cause cave-ins or bank slides, but in no case closer than 3 feet from the edge of excavations.
10. Unauthorized over excavations for footings and foundations shall be filled with approved materials to indicated elevations at no additional expense to the Owner.
11. Condition excavated earth material which is suitable for fill or backfill for re-use and properly stockpile for later filling and backfilling operations as herein specified. Test, screen, and mix as necessary to meet specified requirements.
12. Proceed with caution in areas of utility facilities; expose them by hand excavation or other methods acceptable to the facility owner.
13. If unsuitable materials are encountered at the required subgrades, the Owner may authorize the removal of such unsuitable materials and replacement with suitable compacted fill or with concrete.
14. The Contractor must notify the Owner when any unsuitable material is encountered. The Owner must approve over excavation of unsuitable material prior to commencing excavation of said material.

3.07 SUBGRADE PREPARATION

A. Perform all cutting, blading, and shaping as required to cut and shape the subgrade to the grades and elevations indicated.

B. Subgrade preparation includes fine grading, reworking as necessary, and preparation of cut, fill, or embankment upon which structure and equipment foundations, pipe, subballast, subbase, base, and pavement will be placed.

C. Scarify and mix entire surface of subgrade to a depth of at least 6 inches. Moisture-condition scarified subgrade to 3 percent above optimum moisture content. If subgrade stabilization material is required, incorporate it into subgrade at this time.

D. After the material has been thoroughly mixed and moisture-conditioned, accurately construct and fine grade the subgrade to indicated line, grade, and contour with high and low spots eliminated. Compact for full width to the specified density. Remove soft spots developed during working, fill with approved material, and re-compact.

E. Use mechanical tampers or vibratory compactors.

F. Finish subgrade to straightedge or template within specified tolerances with the finished surface bladed to a uniform, dense, smooth texture.

3.08 FOUNDATION PREPARATION

A. Complete construction of the excavation support and dewatering systems prior to placement of structure and equipment foundations.

B. Avoid disturbing bottom of excavation. If bottom is disturbed, restore and stabilize the bearing foundation at no additional expense to the Owner.

C. If material at bottom of the excavation is rock, remove loose material and roughly level the bearing foundation to indicated elevation. If the bottom contains occasional rock outcroppings or rock in only a portion of the area, remove such rock to a depth of 12 inches below indicated subgrade and backfill with approved material.

3.09 COMPACTION

A. Compaction Density: Compact each layer of embankment, fill, and backfill material to not less than the indicated or specified compaction. Required compactions are defined as Class I or Class II, as follows:
   1. Class I Compaction: 95 percent relative compaction within 2 percentage points of optimum moisture content as determined by ASTM D 698.
   2. Class II Compaction: 97 percent relative compaction within 2 percentage points of optimum moisture content as determined by ASTM D 698.

B. Required Compactions:
   1. Embankment or fill where the surface will be subgrade or bearing foundation for pavements and structures: Class II for full depth.
   2. Backfill around Structures: Class I under top 12 inches; Class II for top 12 inches.
   3. Cut and Cover Backfill: Class I to 36 inches above structure or utility; Class II for balance.
   4. Original Ground or Cut Subgrade: Except as specified in Part 3 Articles, "Subgrade Preparation" and "Foundation Preparation," where original ground or cut subgrade, or fill less than 1 foot thick, will be subgrade or bearing foundation, scarify the surfaces, and provide Class II compaction for at least 12 inches in depth. Include the following additional requirements:

3.10 BACKFILLING

A. Use materials removed from site excavations if such material meets specified requirements.

B. Backfilling is required around all substructures. Fill all abandoned vaults, shafts, airways, adits, holes, pits, and other voids.

C. Place backfill in layers not to exceed 8 inches of loose material, and compact each layer to specified density before the next layer is placed.

D. Place backfill material in such manner that unbalanced horizontal loads will not be applied to a newly-placed structure or portion of structure, utilities, or pipelines. Do not backfill around portions of structures requiring backfill on only one side or on less than all sides, until the concrete has reached the specified strength to withstand the earth pressures.

E. When placing material for backfill around waterproofed structures, protect such structures and the waterproofing thereof with a shield when necessary to prevent displacement or injury by stones or other hard substances in the backfill.

F. Do not backfill on or against structural concrete until the specified 28-day concrete strength has been attained.

G. Do not use compaction equipment and methods that produce excessive horizontal or vertical earth pressures.

3.11 FLOWABLE BACKFILL

A. Place at locations shown on the drawings.
   1. Protect foundation drains from intrusion and contamination of flowable fill by using separation geotextile.
   2. During placement of flowable fill, protect existing structures, drainage facilities, utilities, etc., that are to remain within the fill area from movement or floating, damage or misalignment. Repair or replace any damaged items.

3.12 FINISH GRADING

A. Finish grade all areas to elevations and grades indicated.

3.13 FIELD QUALITY CONTROL

A. Inspections and Tests by the Contractor:
   1. Density Tests: Compacted fill, backfill, and embankment shall be tested to verify compliance with specified requirements in accordance with ASTM D 2922. Minimum frequency of tests shall conform to the following requirements:
      a. One test per lift of fill, backfill, or embankment placed.

2. Tests for compaction shall be made in accordance with test procedures outlined in ASTM D 698. Field testing of soils or compacted fill in place shall be performed in accordance with applicable requirements of ASTM D 2922.
3. Moisture Content Tests: Compacted fill and backfill shall be tested to verify compliance with specified requirements in accordance with ASTM D 3017. Minimum frequency of tests shall be as specified above for density tests.
4. Filling and backfilling tests: perform appropriate field and laboratory tests, as necessary, to evaluate the suitability of fill and backfill material, the proper moisture content for compaction, and the degree of compaction achieved. Fill or backfill that does not meet the specified requirements shall be removed or recompacted until the requirements are satisfied.
    a. Filling and backfilling procedures require approval of the Engineer as they are successively performed. Work found to be unsatisfactory or work disturbed by subsequent operations before approval is granted shall be corrected in an approved manner as directed by the Owner.
5. Flowable Fill Tests: Conduct flowable fill quality tests in accordance with the provisions provided in PENNDOT Publication 408, Section 220.

END OF SECTION

SECTION 31 23 33

TRENCHING AND BACKFILLING

PART 1 GENERAL

1.01 MANDATORY STIPULATION

A. The Specifications Sections “General Conditions to the Construction Contract”, “Special Conditions” and “Division 01 - General Requirements” form a part of this section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.02 SUMMARY

A. Section Includes: Excavating, backfilling, and compacting trenches for pipelines and inline structures, within limits specified or indicated on Drawings.

B. Related Sections:
   1. Cast-In-Place Concrete: Section 03 30 00.

1.03 REFERENCES

A. American Society for Testing and Materials:
   1. ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil using Standard Effort (12,400 ft.-lbf/ft.3).
   2. ASTM D6938, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

B. Commonwealth of Pennsylvania Department of Transportation (PDT), Specifications Publication 408, as supplemented.
   1. PDT Section 220, Flowable Backfill.
   2. PDT section 701, Cement.
   3. PDT Section 703.1, Fine Aggregates.
   4. PDT Section 703.2, Coarse Aggregates.
   5. PDT Section 703.3, Select Granular Material (2RC).
   6. PDT Section 704, Cement Concrete.
   7. PDT Section 704.1 (c), Design Basis.
   8. PDT Section 704.1 (d), Testing and Acceptance.
   9. PDT Section 711.3, Concrete Admixtures.
   10. PDT Section 720.1, Water for Mixing or Curing Cement Concrete, Mortar, or Grout.

1.04 DEFINITIONS

A. Earth Excavation: Removal down to subgrade elevation of clay, silt, loam, sand, gravel, slate, hard pan, pavements, soft sandstone, loose stone in masses, and boulders measuring less than 1/2 cubic yard.

B. Rock Excavation: Removal down to subgrade elevation of large rock and boulders measuring more than 1/2 cubic yard, or other rock requiring continuous drilling and blasting, or drilling and wedging in opinion of Engineer.
   1. Material that can be removed by means other than specified above, but for reasons of economy, removal by drilling and blasting, or drilling and wedging is preferred, will not be classified as rock.
   2. Unless predrilling or predrilling and blasting are approved in advance by Engineer, strip rock for measurement by Engineer. No payment will be made for rock excavated or loosened before measurement.

C. Unclassified Excavation: Material removal of any kind in excavation, including Rock Excavation.

D. Unclassified Excavation Below Subgrade: As specified for Unclassified Excavation except performed below subgrade.

E. Subgrade: Trench bottom prepared as specified to receive Pipe Bedding, Concrete Cradle or Concrete Encasement, or excavation bottom prepared to receive in-line structures.

1.05 SUBMITTALS

A. Test Reports:
   1. Aggregate Material Tests: Submit testing laboratory aggregate test reports based on requirements stated in Quality Control.
   2. Compaction Density Tests: Submit compaction density test reports based on method of density determination as specified in Reference Standards and method approved by Engineer.

B. Aggregate Certificates: Submit certificate from aggregate supplier based on requirements stated in Quality Control, when requested by Engineer.

C. Blasting Plan:
   1. Submit data concerning proposed blasting operations to Engineer, and utility owners if required.

D. Testing Agency: Submit name and qualifications of Testing Agency performing seismographic tests to Engineer for approval prior to proceeding with blasting operations.

1.06 QUALITY ASSURANCE

A. Quality Control:
   1. Laboratory Tests: In accordance with Section 01 45 00, aggregate materials under Part 2 - Products require advance examination or testing according to methods referenced, or as required by Engineer.
      a. Arrange for testing laboratory to furnish Engineer test result reports in triplicate. Test reports are considered sufficient evidence of acceptance or rejection of materials represented.
      b. Conduct aggregate quality tests in accordance with requirements of appropriate Referenced Standard.
      c. Engineer reserves right to accept aggregate materials based on certification from supplier that aggregate originates from a source approved by PennDOT and that aggregate complies with specified PennDOT requirements.

B. Regulatory Requirements:
   1. Work of this Section within State Highway Right-of-Way is subject to inspection by Commonwealth of Pennsylvania Department of Transportation representatives. Perform work in accordance with requirements of latest edition of Commonwealth of Pennsylvania, Pennsylvania Code, Title 67, Transportation, Department of Transportation, Chapter 459, Occupancy of Highways by Utilities.

1.07 PROJECT CONDITIONS

A. General Requirements: Excavate and backfill trenches necessary for completing work of this Contract. Excavate and backfill trenches by machinery or by hand, however, Engineer is empowered, if necessity exists, to direct that hand excavation and backfilling be employed. Perform excavation of whatever substances encountered, to grades and depths indicated on Drawings, as specified, or as directed by Engineer. Remove and waste excavated material not required for backfill.

B. Environmental Requirements:
   1. Do not perform trenching, backfilling or compacting when weather conditions or condition of materials will prevent satisfactory work, in opinion of Engineer.
   2. Do not use frozen materials as backfill or wet materials containing moisture in excess of quantity necessary for satisfactory compaction.
   3. Prior to use, moisten dry backfill material not having sufficient moisture to obtain satisfactory placement or compaction.
   4. Plan work to provide adequate protection during storms with provisions available constantly for preventing flood damage. Protect installed piping and other work against damage from uplift due to high ground water levels.
   5. Accommodation of Drainage: Keep gutters, sewers, drains and ditches open constantly for surface drainage. No damming, ponding, water in gutters, or other waterways permitted, except where stream crossings are necessary and then only to extent Engineer considers necessary. Do not direct water flows across or over pavements except through approved pipes or properly constructed troughs. When

required, provide pipes or troughs of sizes and lengths required at no expense to Owner. Perform grading in vicinity of trenches so that ground surface is properly pitched to prevent water running into trenches.

6. Pumping: Keep excavations free from water during performance of work at no expense to Owner. Build dams and other devices necessary for this purpose and provide and operate pumps of sufficient capacity for dewatering excavations. Provide for disposal of water removed from excavations in a manner not to cause injury to public health, public or private property, work of others, portions of work completed or in progress, or produce an impediment to street, road and highway usage.
7. When necessary to haul soft or wet soil material over roadways, use suitably tight vehicles to prevent spillage. Clear away spillage of materials on roadways caused by hauling.
8. Provide effective dust control by sprinkling water, use of calcium chloride or other method approved by Engineer. Employ dust control when, where and in a manner required by Engineer.
9. Comply with Section 31 25 00, Erosion and Sediment Control.

C. Explosives and Blasting: Not permitted in performance of trenching work.

D. Removal of Rock by Means Other Than Blasting: Where removal of rock by means other than blasting is required, in accordance with requirements of State and local laws, rules and regulations, and utility owner requirements, remove by use of mechanical surface impact equipment, or by drilling and hydraulic rock splitting equipment, or by other methods.

E. Responsibility for Condition of Excavation: Assume responsibility for condition and results of excavation. Remove slides and cave ins at whatever time and under whatever circumstance they occur.

F. Protection: Assume risks attending presence or proximity of overhead or underground public utility and private lines, pipes, conduits and support work, existing structures and property of whatever nature. Assume responsibility for damages and expenses for direct or indirect injury to structures or to person or property by reason of them or by reason of injury to them; whether structures are or are not shown on Drawings, by work of this Contract.
   1. Outside Rights-of-Way: Take necessary precautions to protect trees, shrubs, lawns and other landscaping from damage. Restitution work for damages rests solely with Contractor and at no expense to Owner.
   2. Pipe Supports: Adequately support underground pipes or conduits exposed as a result of excavations. Provide adequate support along entire exposed length by timber or planking. Install supports in a manner that backfilling may be performed without dislodging pipes or conduits. Place and carefully compact required Select Backfill, around supports, and leave in place as a guard against breakage due to backfill settlement. No additional payment will be made for support material left in place nor for labor of installing and maintaining supports.

G. Structure Supports: Where trenching past buildings or structures that by their construction or position might exert detrimental pressure upon trench, right is reserved by Engineer to require that buildings or structures, be underpinned or supported and protected, or special sheeting be driven, or that short lengths of trench be opened at one time.

H. Removal of Obstructions:
   1. Remove, realign or change direction of above or below ground utilities and appurtenant supports, if required in opinion of Engineer. Perform as extra work unless performed by owner of obstruction without cost to Contractor. However, uncover and sustain obstruction at no additional cost prior to final disposition of obstruction. No claims for damage or extra compensation due to presence of obstructions or delay in removal or rearrangement of obstructions will be made. Additional precautions concerning obstructions as follows:
      a. Do not interfere with persons, firms, corporations or utilities employing protective measures, removing, changing or replacing their property or structures, but allow taking measures necessary or advisable under circumstances, without relieving responsibilities of Contract.
      b. Without extra compensation, break through and reconstruct if necessary, invert or arch of sewers, storm drain culvert or conduits encountered if structure is in a position, in judgment of Engineer, as not to require its removal, realignment or complete reconstruction.
      c. Expenses incurred by owner of trackage for shoring his railroad tracks due to trenching adjacent to or tunneling under railroad Right-of-Way is Contractor's responsibility whether billed to him directly or to Owner. Should bills be unpaid by Contractor before final payment of Contract is made, Owner is empowered to pay bill and retain amount from moneys due or to become due Contractor.

I. Pavement Detector Devices: Disturbance of any signal loops will constitute replacement of the entire loop to the nearest junction box. Splicing of loop wires in not acceptable.

J. Advance Trenching: Where existing utilities or other suspected underground obstructions are within close proximity of proposed pipelines, uncover and verify exact location of obstructions far enough in advance of pipelaying to allow changes in pipe alignment or grade required to bypass obstructions and to avoid removing sections of pipe already installed. If sections of installed pipe require removal and reinstallation as a result of not verifying utilities or other underground obstructions far enough in advance, remove and reinstall pipe at no additional cost.

K. Excess Materials: No right of property in materials is granted for excavated materials prior to backfilling. This provision does not relieve responsibility to remove and dispose of surplus excavated materials. Obtain written consent and any necessary permits and approvals before disposing of excess materials at an off-site location.
   1. Conform to DEP Clean Fill Policy.

L. Borrow Excavation: Where required quantity of backfill exceeds quantity of suitable material excavated within limits of Project site and Rights-of-Way, obtain sufficient material to complete backfill at no additional cost to Owner. If borrow excavation is needed, notify Engineer sufficiently in advance of borrow excavation requirements to permit Engineer to verify need for borrow excavation and to view proposed borrow pit and determine suitability of material to be provided. Borrow excavation from outside sources is subject to approval of Engineer. Obtain written consent and any necessary permits and approvals before use of borrow excavation from outside sources.
   1. Conform to DEP Clean Fill Policy.

M. Change of Trench Location or Depth:
   1. Should Engineer require a change in location of a trench from that indicated on Drawings due to presence of an obstruction, or from other cause, and change in location is made before excavation is begun, no extra compensation or claim for damages will be granted.
   2. If a change in trench location made at requirement of Engineer involves abandonment of excavation already made, abandoned excavation, together with necessary refill is classed as unclassified excavation and backfill as applicable, in case full width of trench has not been abandoned.
   3. If a change in trench location made at requirement of Engineer involves abandonment of excavation already made, abandoned excavation, together with necessary refill is classed as earth or rock excavation and backfill as applicable, in case full width of trench has not been abandoned.
   4. If a changed location of a trench is authorized by Engineer upon Contractor's request, Contractor is not entitled to extra compensation or to a claim for damage. If change of trench location involves abandonment of excavation already made, abandoned excavation and refill is at Contractor's expense.

N. Accommodation of Traffic: Do not obstruct streets, roads and highways. Unless Municipality or Governing Agency authorizes in writing complete closing of street, road or highway, employ necessary measures at no expense to Owner to keep street, road or highway open and safe for traffic. Maintain a straight and continuous passageway on sidewalks and over crosswalks, at least three feet wide and free from obstructions. Do Not Obstruct Fire Hydrants.

O. Classification of Excavated Materials: No consideration will be given to nature of materials encountered in trenching operations. Therefore, as unclassified trenching, no additional payment will be made for difficulties occurring in excavating and handling of materials.

P. Maintenance of Roads:
   1. The Contractor shall be responsible during the term of the Contract for the prompt and efficient removal, to the satisfaction of the Engineer and the owners of state, city, borough and township roads, of any soil or other debris deposited on roads or adjacent areas as a result of the Contractor's activities associated with the work to be performed under this Contract.

2. Any potholes, ruts or other damage to existing state, city, borough or township road and adjacent areas which are created by the Contractor's activities shall be immediately repaired to the satisfaction of the owner of the road, using procedures and materials approved by the owner of the road.
3. If the Contractor fails to repair or clean a road surface and adjacent areas in a timely manner or fails to repair or clean the road surface and adjacent areas to the satisfaction of the owner of the road, the owner of the road or the Owner has the right to perform the corrective work and charge the Contractor for the cost incurred. If the Contractor fails to pay the charges, said charges will be deducted by the Owner from the contract bid price.

PART 2 PRODUCTS

2.01 MATERIAL

A. General: All materials to be free of topsoil, plant life, lumber, metal, refuse, coal waste, slag and cinders

B. Approved Backfill: On site excavated soil or soil-rock mixed materials free of rocks or similar hard objects larger than six inches in any dimension. Rocks or similar hard objects are not to represent more than 20 percent of backfill by volume.

C. Select Backfill:
1. On site excavated material free of rocks or similar hard objects larger than one inch in any dimension.
2. AASHTO No. 8 Coarse Aggregate conforming to PDT Section 703.2.

D. Aggregate Backfill: No. 2A Coarse Aggregate conforming to PDT Section 703.2.

E. Pipe Bedding: AASHTO No. 8 Coarse Aggregate conforming to PDT Section 703.2.

F. Reaction Backing, Concrete Cradle and Encasement: Per requirements of Section 03 30 00 and of following Class:
1. H.E.S. concrete materials conforming to PDT Section 704.

G. Underground Warning Tape:
1. Metallic Utility Lines: Printed 4-mil polyethylene non-detectable tape, six inches minimum width, color coded with black ink on APWA (American Public Works Association) approved colors, one inch minimum lettering, printed with name of utility buried below, and suitable for installation in all soil types.
2. Non-Metallic Utility Lines: Printed 5-mil polyethylene aluminum backed, detectable tape, six inches minimum width, color coded with black ink on APWA (American Public Works Association) approved colors, one inch minimum lettering, printed with name of utility buried below, and suitable for installation in all soil types.

3. Provide underground warning tape for the following pipelines and utilities as installed or encountered in the work:
   a. Caution Buried Sewer Line Below - Green.
   b. Caution Buried Water Line Below - Blue.
   c. Caution Buried Gas Line Below - Yellow.
   d. Caution Buried Electric Line Below - Red.
   e. Caution Buried CATV Line Below - Orange.
   f. Caution Buried Communication Line Below - Orange.
   g. Caution Buried Fuel Line Below - Yellow.
   h. Caution Buried Fiber Optic Cable Below - Orange.
   i. Caution Buried High Voltage Line Below - Red.
4. Acceptable Manufacturers:
   a. Seton Identification Products.
   b. Or Approved Equal.

H. Flowable Backfill: Type B conforming to PDT Section 220.
   1. Compressive Strength (PTM No. 604 28 Days): 125 psi.

PART 3 EXECUTION

3.01 PREPARATION

A. Trench Line and Grade: Maintain trench line and grade as follows:
   1. Sewer Lines: Use Engineer's cutsheets as guides for rough excavation, allowing for excavating to accommodate the Pipe Zone Materials, and for Concrete Cradles or Concrete Encasements where indicated on the Drawings or required by the Engineer.
   2. Control Points: Prior to excavation for a run of piping, set control points for line and grade indicated on the Drawings. Compute the depth of cut to pipe line invert from top of grade stakes or other control points. Use the computed depths of cut as guides for rough excavation allowing for excavating to accommodate the required bedding and concrete encasement or cradles.
      a. Set control points sufficiently offset from the trench centerline to prevent loss of the points during the work. Set control points 25-feet apart maximum.
      b. In unpaved areas, mark control points on the top portion of stakes and in paved areas, drive spikes or cut crosses into the paving, both encircled with paint.
   3. Batter Boards and Grade Stakes: As rough excavation is completed set grade stakes or batter boards of rough lumber across the trench opposite the control points. Securely set up and support each batter board to prevent accidental displacement and to ensure each board being leveled equidistant above the pipeline invert.
      a. Run a taut string-line between the batter boards directly over the proposed pipeline centerline. Use the string-line as a control for maintaining pipeline grade and horizontal alignment.

b. To check the vertical distance from string-line to pipe invert, use a grade stake or pole, with a true right-angled offset designed to rest on the pipe invert.
c. Use a plumb line from the string-line to the center of pipe to maintain horizontal alignment.

4. Maintenance of Line and Grade by Other Approved Methods: Subject to the Engineer's prior approval, the Contractor may have the option to use methods customary to the utilities construction industry to maintain lines and grades of pipelines.
   a. Laser: If a laser beam instrument is approved for use by the Engineer, perform field checks of the beam position every fifty feet of installed pipeline. Use survey or other approved method to perform the laser beam position check.

3.02 PERFORMANCE

A. Perform soil erosion control work in accordance with requirements of Section 31 25 00.

B. Excavating: Perform excavation and backfilling using machinery except that hand excavation and backfilling may be required where necessary to protect existing structures, utilities, private or public properties. No additional compensation will be paid for hand excavation and backfilling instead of machine excavation and backfilling as may be necessary.
   1. Remove surface materials of whatever nature, including pavement and topsoil, over line of trenches and other excavations and properly separate and store removed materials as suitable for use in backfilling or other purposes.
      a. Remove pavement in accordance with requirements of Section 32 10 00.
   2. Remove subsurface materials of whatever nature, including rock, masonry and cementitious materials, down to subgrade elevation. Properly separate and store removed subsurface materials as suitable for use in backfilling.
   3. Remove rock to subgrade at least 25 feet in advance of pipe laying.
   4. Remove rock below subgrade if shattered due to excessive drilling and blasting, and in opinion of Engineer it is unfit for foundations. Backfill to subgrade with H.E.S. concrete materials per requirements of Section 03 30 00, or other material acceptable to Engineer. No separate or additional payment will be made for removal and backfill due to excessive drilling and blasting.
   5. Excavate rock in miscellaneous excavations to extent required by Engineer.
   6. When rock is encountered in excavations where blank connections are to be left for future extensions of waterlines, remove rock for a distance of not less than ten feet from blank connection in direction of future extension. Excavate trench to specified width, depth and length.
   7. Remove and waste or otherwise dispose of excavated materials not required for backfill at no expense to Owner.

8. Pre-drilling or pre-drilling and blasting within State Highway Rights-of-Way not permitted. Prior to removal of rock within State Highway Rights-of-Way, strip earth to rock.

C. Trench Width and Depth: For full depth of trench, maximum trench pay width is a vertical plane as specified in Table A. If sheeting is required, Table dimensions apply to the inside face of sheeting.

TABLE A	
Diameter of Pipe	Maximum Trench Width (Outside Diameter of Pipe at Barrel Plus)
3 through 36 inches	24 inches
42 through 72 inches	30 inches
Larger than 72 inches	36 inches

1. Depth: Excavate below planned bottom of pipe, 4 inches in earth and 8 inches in rock.
2. No additional compensation will be paid for excavation beyond trench widths indicated in Trench Width Tables unless approved in writing by Engineer.
3. Excavate rock for manhole, chamber, catch basin or other structure installations 1 foot outside exterior lines of structure walls and to a depth of outside bottom.

D. Trench Width and Depth: For the purposes of measurement and payment only, trench widths and depths have been established as specified herein. No additional compensation will be paid for excavation beyond the specified trench width maximums in the Trench Width Table below.
1. Pipe Embedment Area: In the pipe embedment area (which extends from subgrade elevation to an elevation at least twelve inches above the top of the outside barrel of the pipe), and for measurement and payment purposes only, the trench banks will be considered as nearly vertical and not less than the minimum nor more than the maximum width specified in Table A.

TABLE A		
Diameter of Pipe	Minimum Trench Width (Outside Diameter of Pipe at the Barrel Plus)	Maximum Trench Width (Outside Diameter of Pipe at the Barrel Plus)
through 24 inches	12 inches	16 inches
27 through 36 inches	20 inches	24 inches

42 through 72 inches	26 inches	30 inches
Larger than 72 inches	30 inches	36 inches

2. Remainder of Trench: Beginning at a point twelve inches above the top of the outside barrel of the pipe, and for measurement and payment purposes only, trench banks will be considered as nearly vertical, with the trench width at the top not exceeding the outside diameter of the pipe at the barrel plus the dimensions in Table B.

TABLE B	
Diameter of Pipe	Maximum Trench Width at Top of Trench (Outside Diameter of Pipe at the Barrel Plus)
through 24 inches	40 inches
27 through 36 inches	48 inches
42 through 72 inches	54 inches
Larger than 72 inches	60 inches

3. Excavation Width and Depth for In-Line Structures (Includes Manholes): Excavations will be considered as nearly vertical beginning at bottom of excavation one-foot beyond in-line structure base outside dimension (six inches each side) to two feet beyond in-line structure base outside dimension for top of excavation limit (one foot each side).
   a. If surface pavement of any type is encountered (vehicle or pedestrian ways), cut such pavement to a rectangular shape as opposed to circular shape of in-line structure. Make limits of cut not to exceed one foot beyond top of excavation limit as specified. No additional compensation allowed for surface pavement cuts exceeding the specified limits.
   b. Additionally, should bottom of excavation limit be exceeded, provide without additional compensation, concrete cradle or encasement for pipes entering or leaving manhole or in-line structure.

E. Right-of-way or Easement Restrictions: Where pipelines are constructed in rights-of-way or easements, the work shall be performed in compliance with OSHA, however the maximum trench width shall be kept entirely within the limits of rights-of-way or easements.

F. Excavation Width and Depth for Manhole Rehabilitation: Excavate around the periphery of the manhole frame to a vertical plane one foot outside the walls of the existing top section of the manhole and to a depth of six inches below the top of the existing manhole walls.
   1. Paving Removal: Using a mechanical saw, cut paving to neat lines equidistant from the center line of the manhole. Remove paving one foot beyond specified excavation limits.

G. Additional Trench Width Excavation: The Engineer's written requirement for excavation beyond the maximum allowable trench width shall entitle the Contractor to reimbursement for the quantity of additional excavation at the unit price bid for miscellaneous unclassified excavation and backfill.

H. When unsuitable material is found below subgrade, as determined by Engineer, remove material to a depth determined by Engineer, and provide Pipe Bedding compacted in 4-inch layers.

I. Length of Open Trench: Engineer has right to limit quantity of trench opened in advance of pipe laying and quantity of pipe laid in advance of backfilling, but in no case are these quantities to exceed 300 feet and 100 feet respectively. Complete trench excavation at least twenty-five feet in advance of pipe laying and keep trenches free from obstructions, except that at end of a workday or at discontinuance of work, pipe laying may be completed to within five feet of end of open trench. Additional open trench limitations as follows:
   1. Engineer is empowered to require trench backfilling over completed pipelines at any time if in his judgment it is necessary. No claim for extra compensation will be allowed for trench refilling even though work stopped elsewhere as a result.
   2. If trenching work is stopped for any reason, except as required by Engineer, and excavation is left open for an unreasonable period in advance of construction in opinion of Engineer, Engineer may order trench refilling at no additional expense and not allow trench reopening until ready for actual use.

J. Excavated Material Storage:
   1. In streets, roads, and highways, or in other locations where working space is limited, remove excavated materials from first 100 feet of opening as soon as its excavated, when required by Engineer. Store and return excavated materials for backfilling when required, at no expense to Owner. In no case cast excavated material beyond curb or Right-of-Way lines or on sidewalks or lawns.
   2. Where more material is excavated from trenches than can be backfilled or stored on street or within Rights-of-Way limits, leaving space for traffic and drainage, remove and store excess material. Return excess material for backfilling when required, at no expense to Owner.

K. Subgrade Preparation: Provide Pipe Bedding in trenches as pipe foundations. Depth of Bedding is indicated on Drawings. In lieu of Pipe Bedding, provide concrete encasement or concrete cradle or other type of bedding as indicated on Drawings or required by Engineer. If maximum trench widths specified in Trench Width Table are exceeded, provide concrete cradle or concrete encasement at no expense to Owner.

L. Backfilling: Perform trench backfilling and backfilling excavations for other in line structures by methods resulting in thorough compaction of backfill material without displacement of grade and alignment of pipeline and its appurtenances and minimum settlement of backfilled material. Displacement of pipeline and settlement of backfill will be considered evidence of improper workmanship or inclusion of unsuitable

backfill materials, or both, and will require regrading and realigning pipeline and removing and recompacting settled material at no expense to Owner. Following pipe bedding, piping and inline structure installation, backfill trenches in following manner:

1. State Highway and Shoulder, Municipal Streets, Paved Entrances, Parking Lots, and Driveways: Backfill trenches to a height at least one foot above top of outside barrel of pipe with Select Backfill material placed in four-inch layers. Carefully place this backfill in a manner not to damage or disturb pipe. Backfill remainder of trench with Aggregate Backfill compacted in four-inch layers to bottom of temporary or permanent paving. If vibratory compaction equipment is used, lifts may be 8 inches.
2. Unpaved Shoulder Along Municipal Streets: If edge of trench is three feet or more from edge of road, backfill trench with Select Backfill compacted in four-inch layers flush with existing shoulder. If edge of trench is less than three feet from edge of road, backfill trench with Select Backfill within 18 inches from top of trench; remaining 18 inches to be backfilled with Aggregate Backfill; entire depth to be compacted in 4 inch layers, unless vibratory compaction equipment is used, then lifts may be 8 inches.
3. Unpaved Areas: Backfill trenches to a height at least one foot above top of outside barrel of pipe with Select Backfill material placed in four-inch layers. If vibratory compaction equipment is used, lifts may be 8 inches. Carefully place this backfill in a manner not to damage or disturb pipe. Backfill remainder of trench with Approved Backfill compacted in eight-inch layers to bottom of topsoil. Replace topsoil to approximate depth of existing, as final refill operation and crown to height required by Engineer. Maintain crowned surface as required by Engineer, during guarantee period.
4. Additional Requirements for Piping Bedding and Backfill:
    a. Assure that sufficient Pipe Zone Bedding material is worked under the haunching of the pipe to provide adequate side support.
    b. Prevent movement of pipe during placing of material under the pipe haunch. Walking or standing on pipe will not be permitted.
    c. Excessive tamping of Select Backfill material over the top of the pipe will not be permitted.
    d. Do not use rolling equipment or heavy tampers to consolidate backfill until at least two feet of backfill is placed over the top of the pipe.

M. Earth Dams: Construct Earth Dams composed of On-Site Select Earth Backfill material. Construct Earth Dams in accordance with the Drawing Detail. Place Earth Dam material by hand and compact with proper tools designed especially for such purpose.

1. Locations of Earth Dams:
    a. Construct Earth Dams in main sewer trenches at 100-foot intervals.
    b. Construct Earth Dams at a point not less than three feet upstream from in-line structures.

c. Construct Earth Dams in trenches for service connections at a point not less than three feet from the main sewer trench.
d. Construct additional Earth Dams in trenches at such other locations required by the Engineer.

N. Service Connections: Excavate depth of cut to invert predetermined by Engineer. Where required by Engineer, excavate entire length of service connection trench before laying pipe.
1. Rock Excavation: If rock is encountered within ten feet of buildings, remove by methods other than blasting. Remove rock to one foot beyond end of service connection.
2. Curb and Sidewalk Restoration: If curbs and sidewalks are disturbed during service connection work, restore such at no increase in Contract Price.
3. Markers (For New Installations): Do not backfill upper free end of service connection until elevation and location points are inspected and approved by Engineer. Install a two by four-inch lumber marker set plumb and flush with invert of upper free end of service connection. Cut top of marker flush with existing grade.

O. Backfill for Manhole Rehabilitation:
1. Streets with a Bituminous Concrete Base Course or HMA Base Course:
a. Prior to placing any backfill, paint the outside surface of the manhole walls, leveling units, manhole frame and edges of existing paving with a thin application of PG 64-22 asphalt cement to provide a closely bonded, watertight joint.
b. Backfill the excavation around the manholes with base course material to a point 1 1/2 inches below the top surface of the adjacent existing paving. Place the base course material in layers not more than four inches thick after compaction. The bituminous concrete surface course shall consist of a 1 1/2-inch thick wearing course of ID-2 or HMA bituminous concrete and the completed surface thereof shall be flush with the surface of the adjacent street paving.
2. Streets with a Cement Concrete Base Course:
a. Prior to placing any backfill, paint the outside surface of the manhole walls, leveling units, manhole frame and edges of existing paving with a thin application of PG 64-22 asphalt cement to provide a closely bonded, watertight joint.
b. Backfill the excavation around the manholes with high early strength concrete to a point three inches below the top surface of the adjacent existing paving. The bituminous concrete surface course shall be placed in two courses, consisting of a binder course and a wearing course. The binder course shall not be less than 1 1/2-inches thick after compaction and the wearing course shall not be less than 1 1/2-inches thick after compaction and the completed surface thereof shall be flush with the surface of the adjacent street paving.

P. Underground Warning Tape: For the purposes of early warning and identification of buried pipes during future trenching or other excavation, provide continuous identification tapes in trenches. Install in accordance with printed recommendations of the tape manufacturer, and as specified herein:
   1. Bury tape at a depth of 12-inches below grade. In pavements measure 12-inches from subgrade of pavement.
   2. Provide warning tape in trenches for utilities specified previously.

Q. Compacting: During course of backfilling and compacting work, Engineer may, at any location or depth of trench, require Contractor to perform tests to determine whether compaction operations are sufficient to meet specified requirements. Trench excavation and backfill on State Highway is subject to inspection by representatives of Pennsylvania Department of Transportation. Perform work in accordance with requirements of that department without additional payment regardless if requirements entail more labor or services than methods specified here. Similar inspection and requirements apply to borough street excavations. Compact trench backfill as follows:
   1. Solidly tamp each layer of required backfill around pipeline with proper tamping tools made specially for this purpose.
   2. Thoroughly compact aggregate backfill with a vibratory compactor of type and size satisfactory to Engineer and PennDOT. Compacting of aggregate backfill by puddling or jetting is not permitted.
   3. Use mechanical tampers to compact backfill materials in trench refill operations to produce a density at bottom of each layer of not less than 95 percent of maximum density obtained at optimum moisture content as determined by ASTM D698. Perform field determinations of density, in accordance with ASTM D6938. Make a minimum of two field determinations for each lift of backfill for every 200 ft. length of trench.
   4. From a point one foot above top of pipe to subgrade of paving (or below surface where paving is not required), compact backfill by tamping. Use of Hydra-Hammer for compacting backfill in trenches is prohibited.

R. Embankment Construction for Pipelines:
   1. Embankment Construction: Construct embankments in accordance with the following paragraphs:
      a. Embankment Foundation: Remove existing embankment foundation material when determined unsatisfactory by the Engineer. Refill such areas to original elevation in the same manner specified for formation of embankment.
         1) Scarify embankment foundation surface where embankment three feet or more in height is to be placed. Scarify or otherwise loosen embankment foundation surface to a depth of six inches where embankment less than three feet in height is to be placed.
         2) Existing embankment foundations having a slope steeper than four to one shall be plowed to provide embankment binding when required by the Engineer. On steeper slopes the Engineer may require the foundation to be cut into steps or berms.

3) Fill existing natural depressions or such other depressions resulting from the site work to the level of adjacent ground elevation in the same manner specified for formation of embankment prior to starting initial embankment layer.

b. Formation of Embankment: Use On-Site Backfill material placed in nine-inch layers and each compacted separately using equipment meeting with Engineer's approval. Carry the whole embankment up evenly the required elevation without breaks or irregularities in material distribution or in the formation of layers. Trim embankment slopes and leave in a neat and acceptable condition.
   1) Add water to On-Site Backfill material which does not contain a sufficient amount of moisture to obtain the required compaction. On-Site Backfill material containing moisture in excess of the amount required to obtain the necessary compaction density may not, without written approval, be incorporated in the embankment until allowed to dry to a moisture content not greater than two percentage points above optimum for that particular material.
   2) When pipe is to be laid in fill, bring embankment height to at least four feet above the top of the pipe before the trench is excavated.
   3) Compact embankment material to a minimum final density of not less than 90 percent of the maximum dry weight density at its optimum moisture content.

S. Flowable Backfill: Mix and transport in accordance with PDT Section 704. Submit sequence of operations for approval prior to placement.
   1. Testing and Acceptance: Conforming to PDT Section 704.1(d) except as follows:
      a. Concrete for flowable backfill will be tested for slump in accordance with PTM No. 600, and for yield in accordance with PTM No. 613.
      b. Cylinders for compressive strength testing will be molded in accordance with PTM No. 611 and cured in accordance with PTM No. 611, Section 11.1".

T. Cleanup:
   1. Remove surplus excavated material, rubbish and other construction debris, and keep removed to a point not more than two hundred feet from head of open trench, unless otherwise authorized by Engineer.
   2. After trenches and other excavations are backfilled and work completed, remove surplus excavated materials, rubbish or other materials from work site. Dispose of materials off site in a lawful manner at no additional expense to Owner.
   3. Evenly spread and leave in neat, smooth condition excavated material disposed of lawfully on public property.
   4. Furnish and place topsoil, fertilize and seed grassed areas, within and outside Rights-of-Way affected by construction. Reseed and refertilize areas that fail to show a uniform stand of grass. Water, mow, rake, weed and otherwise maintain grass until final acceptance of Contract.

5. Restore area covered by temporary and permanent Rights-of-Way to as near original conditions as is practical. Bring area up to original grade, place topsoil, seed, replant or replace shrubbery, repair or replace walks, driveways, fences and other improvements, damaged or removed.
6. When repaving over trenches and other excavations is completed, sweep paved surfaces affected by work using hand or power sweepers, and if required by Engineer, flush with water to remove dust and small particles.
7. In case Contractor fails or neglects to do so or makes unsatisfactory progress in doing so, within twenty four hours after receipt of a written notice from Engineer, Owner may remove surplus material and clear roadways, sidewalks and other places, and expense for work charged to Contractor and deducted from moneys due or to become due him under Contract.

U. Maintenance: Assume responsibility for injury or damage resulting from lack of trench maintenance during guarantee period. If trench surfaces are not satisfactorily maintained or repairs begun within seven days after written notice from Engineer, repairs may be made by Owner, and cost charged against Contractor.

END OF SECTION

SECTION 31 25 00

EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.01 MANDATORY STIPULATION

A. The Specifications Sections "General Conditions to the Construction Contract", "Special Conditions" and "Division 01 - General Requirements" form a part of this section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.02 SUMMARY

A. Section Includes: Provision for soil erosion and sedimentation control work as indicated on Drawings.

B. Related Sections:
1. Section 31 20 00: Earthwork.
2. Section 31 23 33.13: Trenching and Backfilling.

1.03 REFERENCES

A. ASTM International (ASTM):
1. ASTM A82; Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
2. ASTM A615; Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
3. ASTM C97; Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone.
4. ASTM D3776; Standard Test Methods for Mass Per Unit Area (Weight) of Fabric.
5. ASTM D3786; Standard Test Method for Bursting Strength of Textile Fabrics—Diaphragm Bursting Strength Tester Method.
6. ASTM D4355; Standard Test Method for Deterioration of Geotextiles from Exposure to Light, Moisture, and Heat in a Xenon Arc Type Apparatus.
7. ASTM D4491; Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
8. ASTM D4533; Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
9. ASTM D4632; Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

10. ASTM D4751; Standard Test Method for Determining Apparent Opening Size of a Geotextile.
11. ASTM D4833; Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.
12. ASTM D4884; Standard Test Method for Strength of Sewn or Bonded Seams of Geotextiles.

B. Commonwealth of Pennsylvania Department of Transportation (PENNDOT) Specifications, Publication 408.
1. PENNDOT Section 703, Aggregates.
2. PENNDOT Section 735, Geotextiles.
3. PENNDOT Section 805, Mulching.
4. PENNDOT Section 806, Water Course and Slope Erosion Protection.
5. PENNDOT Section 850, Rock Lining.
6. PENNDOT Section 865, Silt Barrier Fence.

C. Commonwealth of Pennsylvania, Department of Environmental Protection (PADEP), Bureau of Soil and Water Conservation.
1. Erosion and Sediment Pollution Control Program Manual.
a. Chapter 5, Standards and Specifications.

1.04 SUBMITTALS

A. Furnish certificates from manufacturers of following materials, certifying their products meet requirements of these Specifications.
1. Matting for Erosion Control.
2. Fabric for Silt Barrier Fencing.

1.05 PROJECT CONDITIONS

A. Environmental Requirements:
1. See applicable section for environmental protection, erosion control general requirements, and scheduling.

PART 2 - PRODUCTS

2.01 STONE FOR RIPRAP

A. Provide riprap obtained from an offsite source from an approved PENNDOT Type A source. Do not use stone for riprap protection containing boulders, or cobbles from soil or gravel deposits, earth, roots, debris, or similar material. Each stone to weigh not less than 162 pounds per cubic foot, based on saturated dry specific gravity, determined in accordance with ASTM C97.

B. Provide stone that is predominantly angular and blocky in shape rather than elongated, with sharp clean edges at intersection of relatively flat faces. Following shape limitations are specified for stone used for riprap protection.
   1. Not more than 25 percent of stones reasonably well distributed throughout gradation to have a length more than 2.5 times breadth or thickness.
   2. Do not use stone having a length exceeding 3.0 times its breadth or thickness.

C. Stone for riprap protection obtained from an offsite source to conform to gradation requirements for Rock Lining as specified in PENNDOT Section 850. "R" classification is as indicated on Drawings. Stone protection material may contain up to 5 percent, by weight of air-dried rock, fragments, spalls, and dust with each particle weighing less than permissible minimum stone size and be defined as a stone in stone protection material. In computing percentages by weight of stones in required gradation, do not include weight of a particle weighing less than permissible minimum stone size in total weight.

2.02 MATTING FOR EROSION CONTROL

A. Jute Matting: PENNDOT Section 806.2(a)1.

B. Wood Excelsior Blanket: PENNDOT Section 806.2(a)2.

C. Mulch Control Netting: PENNDOT Section 806.2(d).

D. Nylon Erosion Control Mat: PENNDOT Section 806.2(b)2.

E. Staples: PENNDOT Section 806.2(e).

2.03 EROSION CONTROL DEVICES

A. Straw Bale Barriers:
   1. Bales: Straw stalks of threshed grain or tall hay grass stalks commercially available locally.
   2. Stakes: Wood Stakes. Sound, rough sawn, red, or white cedar or hardwood measuring two inches by two inches; of required length, with tapered point.
   3. Reinforcement Bars: ASTM A615 (S1), Grade 60, Deformed.

B. Wire: ASTM A82.

C. Filter Fabric Fence: PENNDOT Section 865.2.

D. Rock Construction Entrance:
   1. Crushed Stone - PENNDOT Section 703.2, AASHTO No. 1.
   2. Filter Cloth - PENNDOT Section 735, Class 4.

E. Pumped Water Sediment Control Device (PWSCD):
1. Nonwoven geotextile fabric sewn with double needle machine using high strength thread.
2. Provide PWSCD with opening large enough to accommodate a 4-inch discharge hose with attached strap to tie off the hose preventing pumped water from escaping from PWSCD without being filtered.
3. Properties:

PROPERTY	TEST METHOD	TEST RESULT
Weight	ASTM D3776	10 oz./yd.
Grab Tensile	ASTM D4632	270 lbs.
Puncture	ASTM D4833	150 lbs.
Flow Rate	ASTM D4491	70 gal./min./ft.^{2}
Permittivity	ASTM D4491	1.3 sec^{-1}
UV Resistance	ASTM D4355	70%
AOS % Retained	ASTM D4751	100
Seam Strength	ASTM D4884	100 lbs./in.
All properties are minimum average roll value except the weight of the fabric which is given for information only.		

4. Manufacturer:
   a. ACF Environmental, Dirtbag.
   b. Or approved equal.

F. Inlet Sediment Control Device (ISCD):
1. Woven geotextile fabric sack sewn with double needle machine using high strength thread. Geotextile fabric sack to have an average wide width strength of 100 lb/in per ASTM D4884.
2. Provide ISCD manufactured to fit openings of the inlets.
3. Provide ISCD with integral dump straps, lifting loops and restraining strap.

4. Properties:

PROPERTY	TEST METHOD	TEST RESULT
Grab Tensile	ASTM D4632	300 lbs.
Grab Elongation	ASTM D4632	20 Percent
Puncture	ASTM D4833	120 lbs.
Mullen Burst	ASTM D3786	80 psi
Trapezoid Tear	ASTM D4533	120 lbs
UV Resistance	ASTM D4355	80%
Apparent Opening Size	ASTM D4751	40 US Sieve
Flow Rate	ASTM D4491	40 Gal/Min/Sq. Ft.
Permittivity	ASTM D4491	0.55 sec-1
All properties are minimum average roll values.		

5. Manufacturer:
   a. ACF Environmental, Siltsack.
   b. Or approved equal.

G. Channel Inlet Protection: DEP Erosion and Sediment Pollution Control Program Manual Details and Notes and Detail Drawings.

H. Curbed Roadway Inlet Protection: DEP Erosion and Sediment Pollution Control Program Manual Details and Notes and Detail Drawings.

I. Rock Filters: DEP Erosion and Sediment Pollution Control Program Manual, Chapter 5, Section 11.

2.04 TEMPORARY SEEDING MIXTURES

A. As indicated on the Drawings.

Variety of Seed	Spring Mar. 1-May 15	Summer May 15-Aug. 15	Fall & Winter Aug. 15-Mar. 1
	lb. per acre	lb. per acre	lb. per acre
Annual rye grass	20		40
Barley or Oats (local seed)	96		
Millet (Japanese)		35	
Annual rye grass		40	
Winter rye or			168
Winter wheat			180

2.05 SOIL SUPPLEMENT MATERIALS

A. As specified in Section 31 22 19: Finish Grading.

2.06 MULCHING MATERIALS

A. Mulches: As specified in PENNDOT Section 805.2(a)1.

B. Mulch Binding: As specified in PENNDOT Section 805.2(b).

C. Wood Chips: Wood chips, recovered from clearing and grubbing operations is acceptable as mulch for seeding and used at a rate of 35 cubic yard per acre.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Bedding Material for Riprap: Place bedding material uniformly on prepared base, in a satisfactory manner, over areas to receive riprap and to a minimum thickness of 6-inches. Repair damage to surface of bedding base during placement of bedding material or riprap before proceeding with work. Compaction of bedding is not required, but finish to present a reasonably even surface, free from wounds or windows.

B. Riprap: Firmly bed each stone abutting against other stones to form a layer, with interstices filled with suitably sized spalls. Take care in placing stone so that its weight is carried by underlying material and not by adjacent stones. Surface of each stone is not to vary more than 4-inches from surface plane. Depths of abutting stones are not to

differ by more than 4-inches. Progress by fitting additional and abutting stones with well broken joints so that most compact mass of riprap is developed.

C. Trench Plugs:
1. Provide temporary trench plugs at intersections between interceptor terraces and open pipeline trench to prevent unconsolidated soils from being washed down trench during periods of rainfall. Temporary trench plugs consist of eight-foot long dams of compacted earth.
2. Provide permanent trench plugs on critical slopes and on each side of creek crossings to form a solid barrier against subsurface water movement. Permanent trench plugs consist of earth filled sacks packed tightly around pipe.

D. Silt Barrier Fence: Install fence near limits of excavation or fills where indicated on Drawings or as directed by Engineer to control erosion until disturbed areas are permanently stabilized.
1. Construct silt barrier fencing with Class 3 geotextile material with wire or plastic mesh support fencing fastened to support posts. Overall height of fabric above ground to be nominally 18 inches. Provide geotextile material of width required including an 8-inch to 12-inch section for embedment.
2. Excavate a trench 6-inches wide by 6-inches deep on fabric side of barrier and along inside of post line.
3. Install posts a minimum of 18-inches deep, by an approved method, on downstream edge of trench at a maximum spacing of 10-feet.
4. Provide wire or plastic mesh support fence when used, of sufficient height to extend from top of fabric to ground or into excavated trench and be securely fastened to posts. Provide staples for wood posts and tie wires for steel and plastic posts, with a minimum of three fasteners per post.
5. Secure geotextile fabric material by fasteners to top of wire mesh and posts, keeping sag to a minimum, and at a maximum spacing of 30-inches. Extend fabric 8 to 12-inches into excavated trench for embedment. Backfill and compact over geotextile material to prevent water from flowing under fabric. Overlap fabric roll ends a minimum of 6-inches at post locations.
6. Preassembled silt barrier fence systems to be approved by Engineer. Install preassembled fence systems in accordance with manufacturer's recommendations.
7. Construct silt barrier fence across a ditch or swale area of sufficient length to eliminate end flow, with ends pointing upstream and upslope.
8. Maintain silt barrier fence satisfactorily to keep functional. This includes removal of trapped sediment and cleaning fabric of trapped sediment by tapping fabric material when dry. Replace fabric not functioning due to clogging, damage, or deterioration as directed by Engineer.
9. Remove fencing when no longer required, as determined by Engineer. Dispose of fencing materials in a suitable manner and restore area where fence had been erected at no additional cost to Owner.

E. Pumped Water Sediment Control Device (PWSCD):

1. Install the PWSCD on a slope. It should be placed so the incoming water flows into the bag and will flow through the PWSCD and then flow off the site without creating more erosion. The neck of the PWSCD should be tied off tightly to stop the water from flowing out of the PWSCD without going through the walls of the bag. To increase the surface area being used, the PWSCD may be placed on a gravel bed to allow water to flow in all directions.
2. The PWSCD is considered full and should be disposed when it is impractical for the bag to filter the sediment out at a reasonable flow rate and should be replaced with a new PWSCD.
3. Disposal may be accomplished as directed by the Engineer. If the site allows, the PWSCD may be buried on site and seeded, visible fabric removed and seeded or removed from site to a proper disposal area.

F. Inlet Sediment Control Device (ISCD):
1. Installation and emptying instructions in accordance with manufacturers printed instructions.

G. Temporary Seeding and/or Mulching:
1. General: Engineer reserves right to direct temporary seeding and/or mulching of disturbed areas in event permanent grading and seeding cannot be immediately performed. Include cost of temporary erosion control measures in appropriate pay item.
2. Liming: Lime application rates will be determined on basis of tests performed by Contractor or apply a minimum of 800 pounds of agricultural limestone per 1000 square yards.
3. Fertilizer: Apply fertilizer at a rate of 140 pounds per 1000 square yards of 10-20-20 fertilizer or in conformance with results of soil tests performed.
4. Tilling: Till seedbed to a depth of 3 inches prior to seeding. Lime (if required) and fertilizer may be applied during tilling operation.
5. Seeding: Type of temporary seed mixture to be used is determined by Engineer. Sow seed at rate indicated in Temporary Seeding Mixtures Article. Cover seed with 1/2 inch of topsoil and lightly roll seeded area.
6. Mulching: Apply hay or straw mulch at rate of three tons per acre on slopes of 1.5 to 1 or flatter. Apply asphalt material to anchor mulch at rate of 50 gallons per ton on straw or hay mulch. Apply wood cellulose fiber mulch on slopes steeper than 1.5 to 1 at a rate of 1500 pounds per acre. Wood chips, recovered from clearing and grubbing operations, is acceptable as mulch for temporary seeding. Use at a rate of 35 cubic feet per acre in lieu of straw or hay.

H. Mulching Alone: For embankments or cuts 1.5 to 1 or flatter, susceptible to critical erosion during periods of cold weather or other site conditions, Engineer may require a three ton per acre application of straw or hay mulch for temporary erosion control and later seeding. Apply asphalt for anchoring mulch at a rate of 50 gallons per ton. Straw or hay may be rolled immediately with a sheepsfoot roller to anchor mulch in lieu of using asphalt. When weather becomes favorable, seed areas provided with a mulch

cover alone using normal application rates of seed, fertilizer, and lime. If additional mulch is needed, rate of application and area to be mulched will be as determined by Engineer.

I. Matting for Erosion Control: Provide matting in lieu of mulch on slopes 3:1 and steeper or when directed by Engineer.
   1. Prepare area to be covered as a fine seedbed, fertilized, and seeded. Place matting immediately and water to give a firm bond to soil and start germination of seed. Either jute or excelsior matting may be used.
   2. Jute Matting: Lay jute matting snugly to ground with a 4-inch overlap on edges and a 12-inch overlap on ends. Make check slots from a 2-foot-wide strip of jute matting folded and buried in a 6-inch-deep trench with a 6-inch flap extending on each side of trench. Place check slots perpendicular to water flow, tamped and stapled in place before jute matting is laid. Use check slots for jute matting when slope exceeds a 5 percent grade. On grades or slopes steeper than 5 percent, Engineer will determine spacing of check slots.
   3. Excelsior Matting: Lay excelsior matting with netting on top and fibers in contact with soil over entire area. Butt ends and sides of excelsior blanket snugly and staple. It is not necessary to dig check slots, anchor ditches, or bury ends of excelsior matting.
   4. Staples: Hold matting in place by means of wire staples driven at a 90-degree angle to soil surface. Space staples not more than 3 feet apart in three rows for each strip, with one row along each edge and one row alternately spaced in middle. Space staples 6 inches apart across matting ends and check slots width.

3.02 MAINTENANCE

A. Begin maintenance operations immediately and continue throughout construction period until Contract is completed. Inspect sediment control structures and repair after each storm.

3.03 SOIL EROSION AND SEDIMENTATION PLAN

A. An approved Erosion and Sedimentation Control Plan is indicated on Drawings. Should Contractor desire to modify this Plan, obtain necessary approvals prior to implementing any provisions at no additional cost to Owner.

END OF SECTION 312500

SECTION 32 10 00

PAVING AND SURFACING

PART 1 – GENERAL

1.01 MANDATORY STIPULATION

A. The Specifications Sections "General Conditions to the Construction Contract", "Special Conditions" and "Division 01 - General Requirements" form a part of this section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.02 SUMMARY

A. Section Includes: The work specified in this Section consists of the paving and repaving operations for the areas indicated for new bituminous paving.

B. Related Sections:

1. Section 31 20 00: Earthwork.
2. Section 31 23 33.13: Trenching and Backfilling.

1.03 REFERENCES

A. PENNDOT References: The PENNDOT Sections noted herein refer to sections contained in the Commonwealth of Pennsylvania Department of Transportation (PENNDOT) Specifications *Publication 408*, as supplemented. The payment provisions do not apply to work to be performed under this Specifications Section.

1. PENNDOT Section 305 Bituminous Concrete Base Course.
2. PENNDOT Section 350 Subbase.
3. PENNDOT Section 401 Plant Mixed Bituminous Concrete Courses.
4. PENNDOT Section 403 Recycled Plant-Mixed Bituminous Concrete Courses.
5. PENNDOT Section 420 Bituminous Wearing Course ID-2 and Bituminous Wearing Course ID-2, RPS.

6. PENNDOT Section 421 Bituminous Binder Course ID-2 and Bituminous Binder Course ID-2, RPS.
7. PENNDOT Section 460 Bituminous Tack Coat.
8. PENNDOT Section 461 Bituminous Prime Coat.
9. PENNDOT Section 491 Milling of Bituminous Pavement Surface.
10. PENNDOT Section 702 Bituminous Material.
11. PENNDOT Section 703 Aggregates.
12. PENNDOT Section 962, Painting Traffic Lines and Markings.

B. Commonwealth of Pennsylvania Department of Transportation Bulletin 25 and Bulletin 27.

C. ASTM International (ASTM):

1. ASTM D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).
2. ASTM D2167, Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber-Balloon Method.

D. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO T 180, Moisture-Density Relations of Soils Using a ten-pound rammer and an 18-inch Drop.

1.04 DEFINITIONS

A. Specified Maximum Trench Width: The applicable maximum trench width as shown on the Contract Drawings.

B. Street: Unless otherwise specifically qualified herein, the term Street as used in this Section is understood to mean a street, highway, avenue, boulevard, road, alley, lane, driveway, parking lot, or any other area used as a way for vehicles.

1.05 QUALITY ASSURANCE

A. Source Quality Control: Maintain the quality of work by using the products of a qualified bituminous concrete producer and qualified plant operating workmen.

1. Use products of a bituminous concrete bulk producer regularly engaged in production of hot-mix, hot-laid bituminous concrete conforming to the standards referenced herein.

2. Use materials conforming to the requirements of the Commonwealth of Pennsylvania Department of Transportation Specifications *Publication 408*, as supplemented.

B. Workmen Qualifications: Provide at least one person thoroughly trained and experienced in the skills required and who readily understands the design and is completely familiar with the application of bituminous concrete paving work.

1. During progress of bituminous concrete paving work the trained person shall be present to direct the performance of work.

2. For actual finishing of bituminous concrete surfaces and operation of the equipment, use only personnel thoroughly trained and experienced in the skills required.

1.06 PROJECT CONDITIONS

A. Environmental Requirements:

1. Dust Control: Provide effective dust control by sprinkling water, with calcium chloride, or by other methods as approved by the Engineer. Use dust control measures where and when, and in a manner as required by the Engineer.

2. Temperature Limitations: Terminate placement of bituminous concrete surface courses of permanent pavement between October fifteenth and thirty-first, and do not resume placement prior to April first to fifteenth; interim days between date limits may be used for placement as determined by the Engineer depending upon weather temperature conditions.

a. Do not install aggregate courses when ambient temperature is below or is expected to fall below freezing.

b. Do not use aggregate containing frost nor place aggregate courses on frozen subgrade.

c. Do not place bituminous concrete surface courses of permanent pavement when the ambient temperature is 40 degrees F. or lower; nor when the temperature of the pavement, base or binder on which it is to be placed is 40 degrees F. or lower.

3. Paint Application Limitations: Adhere to manufacturer's data on air and surface temperature limits and relative humidity during application and curing of coatings.

a. Do not spray- apply paint when wind velocity is above 15 mph.

b. Schedule painting work to avoid dust and airborne contaminants.

c. Apply paint during daylight hours only.

PART 2 - PRODUCTS

2.01 BASE COURSE MATERIALS

A. Subbase: Composed of Coarse Aggregate Type C (or better) stone conforming to PENNDOT Section 703.2, No. 2A coarse aggregate and as specified in Part 2.3.C of Section 31 20 00: Earth Moving.

B. Bituminous Concrete Base Course: Conforming to PENNDOT Section 305 and Section 403 for RAP requirements.

C. Bituminous Material: Use one of the following conforming to PENNDOT Section 702 and Bulletin 25.

1. Asphalt Cement: Class AC-20.

2.02 SURFACE COURSE MATERIALS

A. Bituminous Materials:

1. Asphalt Cement: AC-20 conforming to PENNDOT Bulletin 25.

2. Bituminous Tack Coat: Class E-1, E-6, or E-8 emulsified asphalt conforming to PENNDOT Bulletin 25.

3. Bituminous Prime Coat: Conforming to bituminous material requirements of PENNDOT Section 461.2(a).

B. Bituminous Pavement Materials:

1. Wearing Course: Hot mixed, hot laid, Bituminous Wearing Course Conforming to PENNDOT Section 420.

C. Traffic Zone Paint: Provide products meeting requirements of PENNDOT Section 962 for the following:

2.03 MISCELLANEOUS MATERIALS

A. Traffic Zone Paint: PENNDOT Section 704:

1. Yellow Traffic Zone Paint: Low-heat, rapid-dry formulation for center lines; reflective.

2. White Traffic Zone Paint: Low-heat, rapid-dry formulation for edgelines and stop bars; reflective.

3. Paint Quality: Paint material composition shall conform to AASHTO Type F paint formulation and AASHTO M-247, Type (standard gradation) for reflective media (glass beads).

2.04 PAVEMENT MIXES

A. Composition of Mixtures: Binder and wearing course mixture composition shall conform to the requirements of PENNDOT Section 401.

1. Establish a job-mix formula prior to beginning work which shall not be changed during the progress of work without the Engineer's approval. Job-mixing tolerances shall not be presumed to permit acceptance of materials whose gradations fall outside the master ranges set in the specified PENNDOT Sections.

2. The approved job-mix formula shall lie within the specification limits and be suitable for the layer thickness and other conditions prevailing. It shall not be changed after work has started without the approval of the Engineer.

PART 3 - EXECUTION

3.01 PREPARATION

A. Subgrade Preparation: Just prior to subbase installation, perform grading and finish rolling.

1. Perform subgrade preparation only after site grading, trenching, etc., have been completed and accepted by the Engineer.

2. The moisture content of the subgrade material at the time of compaction shall not exceed two percentage points above the optimum moisture content.

3. Subgrade over Trenches: Backfill and compact trenches as specified in Section 31 23 33.13: Trenching and Backfilling for Site Utilities.

B. General Requirements for Pavement Removal: Cut existing pavement to neat lines with a mechanical saw.

1. At joints between existing pavements and new paving work, cut and neatly trim the edges of existing pavements in a manner subject to the Engineer's approval. Provide an application of Class AC-20 petroleum asphalt at the locations where new bituminous paving joins existing bituminous paving.

3.02 PERMANENT PAVING INSTALLATION

A. General Requirements: Methods of preparing paving mixture, placing paving mixture, compaction, and protection of in-place bituminous concrete pavement shall comply with PENNDOT Sections 305.3 and 401.3. The specified thicknesses are the compacted thicknesses.

1. Location of types and thicknesses of pavements are delineated on Drawings.

2. Install surface course of replacement pavement with top surface flush with surface of adjacent pavement.

B. Base Course Installation:

1. Bituminous Concrete Base Course: Construct in accordance with the requirements of PENNDOT Section 305.

C. Binder Course Installation:

1. Bituminous Concrete Binder Course: Construct in accordance with the requirements of PENNDOT Section 421.

D. Wearing Course Installation:

1. Bituminous Concrete Wearing Course: Construct in accordance with the requirements of PENNDOT Section 420.

a. Use Bituminous Tack Coat material to seal joints in wearing courses as specified in PENNDOT Section 401.3 (j) 3.

3.03 MISCELLANEOUS MATERIALS INSTALLATION

A. Cement Concrete Curbs: Curbs to shape, thickness, workmanship and finish as delineated on drawings and per referenced specifications unless otherwise required by the Engineer. Construction methods as specified in PENNDOT Section 630.

3.04 PAVEMENT MARKING

A. Paint Application: Strictly follow paint manufacturer's label instructions for mixing, thinning, proper spreading rate, and drying time. In no case shall film thickness be less than manufacturer's recommendations nor shall area coverage per gallon exceed manufacturer's recommendations.

1. Preparation: Prior to pavement marking, clean pavement surface free of contaminants that will prohibit paint adhesion.

2. Thinning: If material has thickened or must be diluted for application, the coating shall be built up to the same film thickness achieved with undiluted material. Do not use thinner to extend coverage of the paint.

3. Coverage Rate: Regardless of the surface condition, apply paint to achieve a suitable finish either by decreasing the coverage rate or by applying additional coats of paint.

4. Provide temporary satisfactory barriers for at least 30 minutes, or until the paint is dry and track free from vehicular traffic. Repaint marked or damaged areas.

B. Parking Area Traffic Lines and Markings: Striping shall consist of white four-inch wide painted lines of length and spacing indicated on the Drawings. Paint lines

accurately with sharp, clearly defined edges. Paint solid colored areas free of skips and holidays. Make linework straight and uniformly spaced.

3.05 MAINTENANCE

A. Continuously maintain temporary pavement without additional compensation until it is replaced with permanent pavement.

B. Without an increase in Contract Price, maintain the work done under this Section for a period as stated in the Agreement after the date of the Owner's approval of the Substantial Completion Certificate issued by the Engineer. Maintenance shall include the repair or removal and replacement of such work which has failed, or wherever surface depressions have developed. Materials and methods used to repair or replace such work shall conform to the applicable requirements of this Section.

C. Should the Contractor fail to perform required maintenance or repairs within three days after receiving written notice from the Owner or Engineer, the Owner may perform such maintenance or repairs and deduct the cost thereof from monies due or to become due the Contractor.

END OF SECTION

SECTION 33 31 19

GRAVITY WASTEWATER UTILITY PIPING

PART 1 GENERAL

1.01 MANDATORY STIPULATION

A. The Specifications Sections “General Conditions to the Construction Contract”, “Special Conditions” and “Division 01 - General Requirements” form a part of this section by this reference thereto and shall have the same force and effect as if printed herewith in full.

1.02 SUMMARY

A. Section Includes: The work specified in this Section consists of constructing the various types and sizes of piped wastewater sewers and appurtenances.

B. Related Sections:
   1. Trenching and Backfilling: Section 31 23 33.
   2. Erosion and Sediment Control: Section 31 25 00.

1.03 REFERENCES

A. American National Standards Institute:
   1. ANSI B16.21, Nonmetallic Gaskets for Pipe Flanges.
   2. ANSI B18.2.1, Square and Hex Bolts and Screws, Including Askew head Bolts, Hex Cap Screws, and Lag Screws.
   3. ANSI B18.2.2, Square and Hex Nuts.

B. American Society for Testing and Materials.
   1. ASTM A 285, Specification for Pressure Vessel Plates, Carbon Steel, Low and Intermediate-Tensile Strength.
   2. ASTM C 144, Specification for Aggregate for Masonry Mortar.
   3. ASTM C 150, Specification for Portland Cement.
   4. ASTM C 301, Method of Testing Vitrified Clay Pipe.
   5. ASTM C 361, Specification for Reinforced Concrete Low-Head Pressure Pipe.
   6. ASTM C 425, Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
   7. ASTM C 443, Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
   8. ASTM C 923, Specification for Resilient Concrete Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals.
   9. ASTM C 924, Standard Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method.

10. ASTM D 1784, Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
11. ASTM D 2000, Standard Classification System for Rubber Products in Automotive Applications (SAE Recommended Practice J200).
12. ASTM D 2321, Recommended Practice for Underground Installation of Flexible Thermoplastic Sewer Pipe.
13. ASTM D 2680, Specification for Acrylonitrile-Butadiene-Styrene (ABS) and Poly (Vinyl Chloride) (PVC) Composite Sewer Piping.
14. ASTM D 2751, Specification for Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe and Fittings.
15. ASTM D 3034, Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
16. ASTM D 3212, Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
17. ASTM F 477, Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
18. ASTM F 679, Specification for Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
19. ASTM F 789, Specification for Type PS-46 Poly (Vinyl Chloride) (PVC) Plastic Gravity Flow Sewer Pipe and Fittings.
20. ASTM F 794, Specification for Poly (Vinyl Chloride) (PVC) Ribbed Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.
21. ASTM F 1803, Standard Specification for Poly(Vinyl Chloride)(PVC) Closed Profile Gravity Pipe and Fittings Based on Controlled Inside Diameter.

C. Uni-Bell Plastic Pipe Association:
   1. UNI-B-6, Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe.

1.04 SYSTEM DESCRIPTION

A. Design Requirements:
   1. Provide one type and class of pipe in continuous line of sewer between structures, unless otherwise indicated on the Drawings.
   2. Provide pipe and fittings designed to withstand imposed trench loadings and prevailing site conditions at the various locations.

1.05 SUBMITTALS

A. Shop Drawings and Product Data: Submit completely dimensioned shop drawings, catalog cuts and such other data as required to provide complete descriptive information for the following:
   1. Sewer Pipe and Fittings
   2. Piping Specialties

B. Certificates: Submit certified records or reports of results of shop tests, with such records or reports containing a sworn statement that shop tests have been performed as specified.
   1. Manufacturer's sworn certification stating that the pipe will be manufactured in accordance with specified reference standards for each pipe type.

1.06 QUALITY ASSURANCE

A. Source Quality Control:
   1. Shop Tests: Perform, as a condition of the Contract, factory tests of pipe materials listed in the following. Each pipe manufacturer is to have facilities to perform the listed tests. The Engineer reserves the right to require the manufacturer to perform such additional number of tests as the Engineer may deem necessary to establish the quality of the material offered for use.

MATERIAL	TEST METHOD	NUMBER OF TESTS
Solid Wall Polyvinyl Chloride (PVC)Pipe	ASTM D 3034 or ASTM F 789 or ASTM F 679	As specified in ASTM D 3034 ASTM F 789 or ASTM F 679

   2. Laboratory Tests: The Engineer reserves the right to require that laboratory tests also be conducted on materials that are shop tested. Furnish without compensation, labor, materials, and equipment necessary for collecting, packaging, and identifying representative samples of materials to be tested and the shipping of such samples to the Testing Laboratory. These laboratory tests will be paid for as provided in the Bid Form from the fund stipulated for the purpose.

1.07 DELIVERY, STORAGE AND HANDLING

A. Transport, handle and store pipe materials and the associated materials specified herein, in the manner recommended by the respective materials manufacturers to prevent damage and defects to their respective materials.

1.08 PROJECT CONDITIONS

A. Environmental Requirements: In addition to the environmental requirements of the manufacturers of the pipe products used, comply with the following:
   1. Keep trenches dewatered until pipe joints have been made and concrete cradle and encasement (as required) have cured.
   2. Do not lay pipe in water or on bedding containing frost.
   3. Do not lay pipe when weather conditions are unsuitable for pipe laying work, as determined by the Engineer.

B. Sewer Pipe and Fitting Options: The Contractor is allowed the option to provide one type of pipe in the project of the types listed hereinafter for a particular listed pipe size range.
   1. Pipe Material Types:
      a. Six through 15-inch diameter:
         1) Polyvinyl Chloride pipe (PVC), SDR-35 or PS-46.

PART 2 PRODUCTS

2.01 PIPE AND FITTINGS

A. Elastomeric Gaskets: For pipe joint gasket material, provide elastomeric gaskets that have been tested as suitable for continuous contact with domestic sewage.

B. Solid Wall Polyvinyl Chloride (PVC) SDR Pipe: Provide pipe which is permanently marked with manufacturer's trademark, size and conformance designation.
   1. Pipe, Solid Wall, Size 6 through 15-Inch Diameters: Type PSM SDR-35 conforming to ASTM D 3034 requirements, or Type PS-46 conforming to ASTM F 789 requirements for pipe sizes above 15-inch to 18-inch diameter.
   2. Pipe, Solid Wall, Size 18 through 27-Inch Diameters: Type PS-46 conforming to ASTM F 679 requirements.
   3. Fittings: Commercially manufactured molded fittings made from PVC compounds having a cell classification of 12454-B, 12454-C,or 13343-C as defined in Specification ASTM D 1784.
   4. Joints: Push-on style joint, with elastomeric gasket, conforming to ASTM D 3212 requirements for joint design; gasket conforming to ASTM F 477 requirements for material specifications, providing a watertight seal.
      a. Incorporate the gasket locked in a grove as part of pipe bell design to prevent gasket displacement when pipes are joined.
      b. Incorporate the gasket locked in a grove as part of pipe bell design to prevent gasket displacement when pipes are joined.

2.02 PIPING SPECIALTIES

A. Non-Shrink Non-Metallic Grout: As specified in Section 03 60 00.

B. PVC Waterstop: Use PVC waterstop in making a grouted connection of piping to existing manholes or structures. Waterstop construction as follows:
   1. Gasket type waterstop composed of virgin polyvinyl chloride (PVC) material.
   2. Acceptable Manufacturers:
      a. FERNCO Inc., CMA Concrete Manhole Adapter, Distributed by the General Engineering Company.
      b. Or equal.

C. Sleeve Type Pipe Seal: Use sleeve type pipe seal in making a core-drilled connection of piping to existing manholes or structures. Pipe seal construction as follows:

1. In general, the pipe seal is to conform to the requirements of ASTM C 923 and incorporate a positive compression fit of the gasket to both the manhole and the pipe.
2. Acceptable Manufacturers:
   a. Press-Seal Gasket Corp., Concrete Products Supply Co.; PSX Seal.
   b. Or equal.

D. Modular, Mechanical Type Pipe Seal: Use modular, mechanical type pipe seal in making a core-drilled connection of piping to existing manholes or structures. Pipe seal construction as follows:
1. The seal is to consist of inter-locking synthetic rubber links shaped to continuously fill the annular space between the pipe and the wall opening.
2. Size and select the elastomeric element of the seal in accordance with the seal manufacturer's recommendations. Elastomeric element is to conform to ASTM D 2000 requirements for EPDM material.
3. Provide hardware in the seal as recommended by the seal manufacturer for buried service such as will exist at the project site.
4. Acceptable Manufacturers:
   a. Thunderline Corporation; Link-Seal.
   b. Or equal.

E. Flexible Pipe Couplings: Use flexible pipe couplings in making connections of differing pipe material, and for transition/reducing conditions of differing pipe material connections.
1. Coupling Construction: Composed virgin polyvinyl chloride (PVC) material which meets the performance requirements of Commercial Standard Specification CS 226-59. Incorporate recesses in couplings designed for pipe outside diameter coupling to contain two stainless steel bands. Couplings provided with two pre-assembled type 305 stainless steel bands.
2. Shear Rings: Provide band-type construction shear rings designed to reduce the possibility of shear failure of the Flexible Pipe Coupling. Shear rings fabricated of AISI Type 300 series stainless steel sheet and provided complete with pre-assemble AISI Type 305 stainless steel screw bands. Provide the proper style shear ring, including bushings as necessary, as is suited for the Flexible Pipe Coupling being used.
3. Acceptable Manufacturers:
   a. FERNCO Inc., Distributed by the General Engineering Company.
   b. Or equal.

F. Exterior Joint Collar: Flexible, multi-layered, bitumastic-compound material, waterproof collar with stainless steel strap and clamp assemblies. Overlap the joint collar to the pipe joint a minimum of nine inches on each side of the joint.
1. Acceptable Manufacturers:
   a. Mar-Mac Manufacturing Co., McBee, S. Carolina; MacWrap Exterior Joint Sealer.

b. Or equal.

PART 3 EXECUTION

3.01 EXAMINATION

A. Field Inspection: Inspect each section of pipe and each pipe fitting before laying in conformance with the inspection requirements of the appropriate referenced standard.

B. Rejected Products: Remove rejected Products from the Project site and replace with new Products at no increase in Contract Price.
   1. Pipe already laid and later found defective will not be accepted and require its replacement at no increase in Contract Price.

3.02 PREPARATION

A. General Requirements: Clean piping interior prior to laying pipe and following pipe laying and keep open ends of piping and pipe attachment openings capped or plugged until actual connection or actual pipe testing.
   1. Provide the protective means to prevent water and debris from washing into the pipe.

B. Earthwork: Perform earthwork for gravity sewer installation as specified in Section 31 23 33.
   1. Bedding materials and concrete work for pipe bedding as specified in Section 31 23 33.
   2. Excavate trenches in rock at least 25-feet in advance of pipe laying. Protect pipe ends from rock removal operations.

3.03 CONSTRUCTION

A. General Requirements: Use proper and suitable tools and appliances for the proper and safe handling, lowering into trench and laying of pipes.
   1. Lay pipe proceeding upgrade true to line and grades given. Lay bell and spigot pipe with bell end upgrade. Lay tongue and groove pipe with groove end upgrade. No wedging or blocking permitted in laying pipe unless by written order of Engineer.
   2. Exercise care to ensure that each length abuts against the next in such manner that no shoulder or unevenness of any kind occurs along inside bottom half of pipeline.
   3. Before joints are made, bed each section of pipe full length of barrel with recesses excavated so pipe invert forms continuous grade with invert of pipe previously laid. Do not bring succeeding pipe into position until the preceding length is embedded and securely in place. Dig bell holes sufficiently large to permit proper joint making and to ensure pipe is firmly bedded full length of its barrel.

4. Walking or working on the installed pipeline, except as necessary in tamping and backfilling, is not permitted until trench is backfilled one-foot deep over top of pipes.
5. Take up and relay pipe that is out of alignment or grade, or pipe having disturbed joints after laying.

B. Pipe Laying and Joining: Perform pipe laying and joining in strict accordance with manufacturer's installation instructions, reference standards as included, and such additional requirements as specified herein.
1. Arrange and pay for pipe manufacturer's representative to be present for first installation of pipe to instruct workmen on proper installation methods.
2. Make joints absolutely watertight and immediately repair detected leaks and defects. Methods of repair subject to Engineer's approval.
3. Laying/Joining Specified Types of Plastic Pipe: Installation and joint assembly according to ASTM D 2321 requirements and for Class I bedding material as included therein.

C. Drop Connections: Make drop connections where indicated on the Drawings, where drop in invert is two feet or more or as required by the Engineer. Use same pipe material used to construct the main from which the drop connection is made. Construct drop connection in accordance with design shown on Detail Drawing.

D. Connections of Piping to Existing Manholes or Structures: The option is allowed to construct pipe connections to existing manholes or structures by one of the methods stated herein, except where indicated otherwise on the Drawings. A mixture of connection methods is not allowed.
1. Cut-in Opening Utilizing PVC Waterstop and Grout: Cut required opening or openings by such methods so as to prevent cracking and spalling concrete. Make openings of sufficient size to accommodate the pipe with PVC Waterstop installed and one inch of annular grout space. Grout annular space using Non-Shrink Non-Metallic Grout as specified in Section 03 60 00. Make connection watertight.
2. Core-drilled Opening Utilizing Sleeve Type Pipe Seal: Core-drill the required opening or openings using the proper equipment for the work. Make openings of sufficient size to accommodate the Pipe Seal.
3. Core-drilled Opening Utilizing Modular, Mechanical Type Pipe Seal: Core-drill the required opening or openings using the proper equipment for the work. Make openings of sufficient size to accommodate the Pipe Seal.
4. Grouting the Connection: Following pipe installation through the seal, grout the annular space at the pipe connection, on both sides of the wall, to the spring line of the pipe. Finish the grout smooth and flush with face of manhole.
5. New Invert Channel: Regardless of the connection to existing manhole option selected, form a new invert channel in the existing manhole base to properly conduct the flow through the existing manhole. Do not permit ground water, surface water or debris to enter the existing facilities through the new connection.

a. Use Non-Shrink Non-Metallic Grout to form the new invert channel.

E. Replacement of Damaged Sewer Segments: Remove existing damaged pipe to the limits indicated on the Drawings or as designated by the Engineer and replace with new pipe.
1. When the remaining pipe ends in a bell, remove the bell by cutting with a mechanical saw. Removing the bell or other pipe sections by hammering or chiseling is not permitted.
2. Make connection of new pipe to remaining existing pipe using Flexible Pipe Couplings. Provide reducing Flexible Pipe Coupling where required to accommodate differing pipe materials.

3.04 FIELD QUALITY CONTROL

A. General Requirements: Conduct tests specified herein so that each pipeline installed in the Project is tested to the Engineer's satisfaction.
1. Provide tools, materials (including water), apparatus and instruments necessary for pipeline testing.
2. Conduct tests in the presence of and to the satisfaction of the Engineer.

B. Testing Equipment: Use air compressing apparatus equipped with a control panel with necessary piping, control valves and gauges to control air flow rate to piping test section, and to monitor air pressure within piping test section and air pressure within test section seal plugs.
1. To prevent accidental overloading of piping test section, provide air compressing apparatus with an approved pressure relief device set to relieve at ten psi.
2. Provide an extra pressure gauge of known accuracy to frequently check test equipment and apparatus.
3. Air testing equipment and associated testing apparatus subject to Engineer's approval.
4. Provide GO-NO-GO Mandrel and incidental equipment for Deflection Test. Mandrel to conform to following requirements:
a. Cylindrical in shape with not less than nine arms spaced evenly around the mandrel.
b. Minimum contact length of mandrel arms with pipe wall not less than the nominal diameter of the pipe being tested.
c. Mandrel diameter 95 percent of inside pipe diameter.

C. Cleaning Prior to Tests: Before tests are conducted, flush piping including sewers and branches until free of all forms of dirt and construction debris.
1. Provide the water for the flush cleaning operation from the Contractor's source.

D. Initial Section Test: To demonstrate acceptability of installed pipe materials and workmanship, construct and air test one sewer section from manhole to manhole using the pipe provided in the Contract. Pretesting such section prior to actual Initial Section Test not permitted.

1. Conduct Initial Section Test in same manner as Line Acceptance Test specified in a following paragraph.
2. Conduct the Initial Section Test for each size and type pipe material used in the Project prior to continued installation of same pipe.
3. Provide pipe manufacturer's representation during laying, backfilling and testing of Initial Sections Tests.
4. The Engineer has the option to order the same Initial Section Test for a section of sewer in each 3,000 lineal feet of sewer line of a particular size and material.
5. Conduct same Initial Section Test for one manhole to manhole sewer section of each 3,000 lineal feet of sewer.
6. Failure of an Initial Section Test will be sufficient cause for the Engineer to reject manufacturer and supplier of pipe regardless of cause of failure.
7. Sewer sections successfully tested as Initial Section Test will be retested under Line Acceptance Test.

E. Line Acceptance Test: After a section of sewer is constructed between adjacent manholes, backfilled and successfully cleaned, perform a low-pressure air Line Acceptance Test in accordance with the following and the Standards listed therein:
   1. Plug free ends of branches.
   2. Seal Sewer piping at upstream and downstream manholes with pneumatic type plugs. Test plug seal before actual use by testing plugs outside the trench in one length of pipe pressurized to maximum anticipated testing pressure. Plugs to hold without bracing and show no movement.
   3. Introduce low pressure air slowly into sealed sewer section until internal air pressure is four psig greater than the average ground water pressure acting on the pipe.
   4. Allow two minutes minimum for air temperature to stabilize, adding only required air to maintain pressure.
   5. After stabilization period (3.5 psig minimum in pipe) disconnect air supply and determine rate of air loss by measuring time interval required for 3.5 psig to decrease to 2.5 psig greater than the average groundwater pressure acting on the pipe.
   6. To determine the groundwater pressure acting on the pipe being tested, divide the height in feet of the groundwater above the invert of the pipe by 2.3. Add the result to the previously specified test pressures (i.e., If maximum groundwater height is 11.5 feet above the pipe invert, the groundwater pressure is five psig. This increases the 3.5 psig and 2.5 psig to 8.5 psig and 7.5 psig, respectively.) Test pressure not to exceed ten psig regardless of height of groundwater over the pipe.
   7. Consider sewer line Acceptable when a 1.0 psig pressure drop does not occur within the test time specified in the AIR TEST TABLES immediately following this Section.
   8. Test Standards:
      a. PVC Pipe, Solid Wall: Test according to UNI-B-6.

F. Deflection Test: In addition to air tests and infiltration test, conduct deflection tests on PVC (and ABS) pipe. Test each PVC pipe sewer main installed. (Test one section of ABS pipe sewer main selected by Engineer, between adjacent manholes for each 3,000 feet of ABS pipe sewer main installed.)
   1. Conduct deflection testing not less than 30 days after section of pipe sewer main between adjacent manholes is backfilled.
   2. Pull mandrel through pipe section manually; powered pulling devices not permitted.
   3. Consider sewer line section which mandrel cannot pass through, to have more than maximum allowable deflection of five percent.
   4. If a test section of ABS pipe sewer main has more than the maximum allowable deflection, deflection test ABS pipe sewer sections not previously tested.

G. Infiltration Test: In addition to air tests and deflection test specified previously, conduct infiltration tests at such time and manner required by Engineer.
   1. Infiltration rate of groundwater or other water into the sewer line, including manhole bases and walls, exceeding 100 gallons per inch diameter per mile of sewer per day during periods of high groundwater levels will be considered evidence of defective material or improper workmanship.
   2. Make repairs and replacements as required, if rate of infiltration exceeds allowable maximum rate.
   3. Regardless of whether the rate of leakage exceeds or is below the allowable maximum rate, repair leaks in pipe sewer lines.

H. Repair and Retest: When section or sections of sewer fails to meet test requirements specified previously, determine source or sources of leakage, repair or replace defective material, and if as result of improper workmanship, correct such.
   1. Take up and relay pipe sewer line section that has more than the maximum allowable deflection.
   2. Conduct additional tests required to demonstrate that sewer line meets specified tests requirements.

I. Owner's Tests: The Owner reserves the right to retest at its expense, any piping throughout the duration of the Construction Period.
   1. Make repairs as Work of this Contract to piping found defective by such Owner conducted tests.

END OF SECTION