PROJECT MANUAL

ADVANCED PROTEIN CRYSTALLIZATION FACILITY (APCF)

9700 S. Cass Avenue
Lemont, IL 60439

CONSTRUCTION DOCUMENTS

PROJECT NO.: **22378.000**

ISSUE DATE: **JULY 3, 2012**

ISSUED FOR: **CONSTRUCTION**

VOLUME 3 – DIVISIONS 26 - 33

SmithGroup Incorporated
35 East Wacker, Suite 2200
Chicago, IL 60601

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SECTION 26 00 00

GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.2 DESCRIPTION

A. Intent of drawings and Specifications is to obtain complete systems tested, adjusted, and ready for operation.

B. Except as otherwise defined in greater detail, the terms "provide", "furnish" and "install" as used in Division 26 Contract Documents shall have the following meanings:
   1. "Provide" or "provided" shall mean "furnish and install".
   2. "Furnish" or "furnished" does not include installation.
   3. "Install" or "installed" does not include furnishing.

C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.

D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.

E. Included in this Contract are electrical connections to equipment provided by others. Refer to Architectural, Mechanical, Plumbing, and final shop drawings for equipment being furnished under other sections for exact locations of electrical outlets and various connections required.

F. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for dimensions.

G. Where architectural features govern location of work, refer to Architectural Drawings.

H. Perform work in "neat and workmanlike" manner as defined in ANSI/NECA 1, Standard Practices for Good Workmanship in Electrical Contracting.

1.3 RELATED WORK

A. Utility Services:
   1. Determine utility connection requirements and include in Base Bid all costs to ANL for utility service.
   2. Include costs for temporary service, temporary routing of service or other requirements of a temporary nature associated with utility service.

B. Temporary Services:
   1. Division 01 - Temporary Facilities and Controls.

C. Continuity of Service:
   1. No service shall be interrupted or changed without permission from ANL. Obtain written permission before work is started.
   2. Notify ANL where interruption of services is required, Agree to specified time for service interruption

D. Demolition:
   1. Perform required demolition to accomplish new work.
      a. Remove abandoned wiring to source of supply.
      b. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
      c. Disconnect abandoned outlets and remove devices.
      d. Remove abandoned outlets if conduit servicing them is abandoned and removed.
      e. Provide blank cover for abandoned outlets that are not removed.
      f. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
      g. Disconnect and remove abandoned luminaries. Remove brackets, stems, hangers, and other accessories.
      h. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.
   2. Accomplish work in neat workmanlike manner to minimize interference; annoyance or inconvenience such work might impose on ANL or other Contractors.
   3. Unless otherwise noted, remove from premises materials and equipment removed in demolition work.
   4. Equipment noted to be removed and turned over to ANL, shall be delivered to ANL at place and time ANL designates.
   5. Where materials are to be turned over to ANL or reused and installed by Contractor, it shall be Contractor's responsibility to maintain condition of materials and equipment equal to that existing before work began. Repair or replace damaged materials or equipment at no additional cost to ANL.
   6. Where demolition work interferes with ANL's use of premises, schedule work through Architect, ANL and with other Contractors to minimize inconvenience to ANL. Architect must approve schedule before Contractor begins such work.

E. Cleaning and Repair
   1. Clean and repair existing materials and equipment that remain or are to be reused.
   2. Panelboards.
      a. Clean exposed surfaces and check tightness of electrical connections.
      b. Replace damaged circuit breakers and provide closure plates for vacant positions.
      c. Provide typed circuit directory showing revised circuiting arrangement.
   3. Luminaires:
      a. Remove existing luminaries for cleaning.
      b. Use mild detergent to clean exterior and interior surfaces; rinse with clean water and wipe dry.
      c. Replace lamps, ballasts, and broken electrical parts.

F. Concrete Work:
   1. Provide cast-in-place concrete as required by Contract Documents unless otherwise noted.
   2. Concrete shall comply with Division 03 - Concrete.
   3. Provide anchor bolts, metal shapes and templates to be cast in concrete or used to form concrete as required for anchoring and supporting electrical equipment. Hardware material shall be non corrosive or stainless steel.
   4. Concrete work for outdoor equipment shall be coordinated to accommodate conduit stub-up(s) and equipment grounding. Contractor shall coordinate this effort prior to the work, or relocation may be required at Contractor’s burden.

G. Painting:
   1. Furnish equipment with factory-applied finish coats or paint equipment per Division 09 – Finishes unless specified otherwise.
   2. Furnish equipment with factory applied prime finish unless otherwise specified.
   3. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Architect.
   4. Furnish one can of touch up paint for each final factory-applied finish coat of product.
   5. All exposed threads of exterior metal conduit shall be painted to avoid rusting.

1.4 REQUIREMENTS OF REGULATORY AGENCIES

A. Rules and regulations of Federal, State and local authorities and utility companies, in force at time of execution of Contract shall become part of this specification.

1.5 REFERENCE STANDARDS

A. Agencies or publications referenced herein refer to the following:
   1. AEIC Association of Edison Illuminating Companies
   2. ANSI American National Standards Institute
   3. ASME American Society of Mechanical Engineers
   4. ASTM American Society for Testing and Materials
   5. BICSI Building Industry Consulting Services International
   6. EIA Electronic Industries Association
   7. FIPS Federal Information Processing Standards
   8. FCC Federal Communications Commission
   9. ICEA Insulated Cable Engineers Association
   10. IEEE Institute of Electrical & Electronics Engineers
   11. IESNA Illuminating Engineering Society of North America
   12. NEC National Electrical Code
   13. NECA National Electrical Contractors Association
   14. NEMA National Electrical Manufacturers Association
   15. NESC National Electrical Safety Code
   16. NETA National Electrical Testing Association
   17. NFPA National Fire Protection Association
   18. NIST National Institute of Standards & Technology
   19. OSHA Occupational Safety and Health Administration
   20. TIA Telecommunications Industries Association
   21. UL Underwriters Laboratories, Inc.

B. Work shall be in accordance with latest edition of codes, standards or specifications unless noted otherwise.

1.6 LISTING

A. Install materials bearing UL label or UL listing, unless UL label or listing is not available for that type of material.

B. Other nationally recognized testing agencies, acceptable to AHJ, are approved.

1.7 ENCLOSURES

A. Typical NEMA Enclosures and Usage
   1. NEMA 1 - Indoors. Falling dirt.
   2. NEMA 3R - Outdoors. Rain, snow, sleet.
   3. NEMA 3RX - Same as NEMA 3R plus corrosion resistant.
   4. NEMA 12 - Indoors. Falling Dirt. Falling liquids. Flying dust, lint and fibers. Oil or coolant seepage.

1.8 SUBMITTALS

A. Shop Drawings (Product Data):
   1. Refer to Division 01 - Submittal Procedures.
   2. Note that for satisfying submittal requirements for Division 26, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 01. However, the expression "Shop Drawings" is generally used throughout Specification.
   3. Submit shop drawings for equipment and systems as requested in respective specification sections. Submittals which are not requested may not be reviewed.
   4. Specifically mark general catalog sheets and drawings to indicate specific items submitted and its correlation to specific designation for product in drawings.
   5. Specifically indicate proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
   6. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Clearly mark and note submittal accordingly.
   7. Submit complete record of required components when luminaires, equipment and items specified include accessories, parts and additional items under one designation.
   8. Include wiring diagrams for electrically powered or controlled equipment.
   9. Submit electrical equipment room layouts drawn to scale, including equipment, raceways, accessories and required working clearances. Submit electrical equipment room layouts concurrently with electrical distribution equipment submittals.
   10. Where submittals cover products containing non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
   11. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
   12. Submittals that are not complete, not permanent, or not properly checked by Contractor, will be returned without review.
   13. "Coordination Drawings", which are normally prepared by Contractor to coordinate work among various trades and to facilitate installation, shall not be submitted for Division 26 work unless specifically requested in technical sections. These types of drawings typically include dimensioned piping, ductwork or electrical raceway layouts.
   14. Unless specifically requested in Division 26 technical sections, submittals of coordination drawings will be returned without review.

B. Certificates and Inspections:
   1. Obtain and pay for inspections required by authorities having jurisdiction and deliver certificates approving installations to ANL unless otherwise directed.

C. Operation and Maintenance Manuals:
   1. Refer to Division 01 - Operation and Maintenance Data.

2. Upon completion of work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2" thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to ANL.
3. Organize manuals by specification section number and furnish table of contents and tabs for each piece of equipment or system.
4. Manuals shall include the following:
   a. Copies of shop drawings
   b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment, with component exploded views and part numbers. Where manufacturer's data includes several types or models, designate applicable type or model.
   c. CD ROM's of O&M data with exploded parts lists where available
   d. Phone numbers and addresses of local parts suppliers and service companies
   e. Internet/WEB page addresses where applicable
   f. Wiring diagrams
   g. Start up and shut down procedure
   h. Factory and field test records
   i. Additional information, diagrams or explanations as designated under respective equipment or systems specification section
5. Instruct ANL’s representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
6. Furnish O&M manuals and instructions to ANL prior to request for final payment.
7. Where loads imposed exceed design superimposed dead loads or suspended loads specified in contract documents, submit for approval to Structural Engineer of Record loads imposed on the primary structural frame. Submittal shall include location, magnitude and direction of imposed loads (basic, unfactored load cases), graphically represented in their appropriate locations on a copy of the Contract Document structural framing plans or elevations as appropriate. Detail references indicating the connections applicable at each location shall be noted on the submittal drawings.

D. Record Documents:
   1. Refer to General Conditions of Contract and Division 01 - Project Record Documents. Prepare complete set of record drawings in accordance with Division 01.
   2. Use designated set of prints of Contract Documents as prepared by Architect to mark-up for record drawing purposes.

1.9 JOB CONDITIONS

A. Building Access:
   1. Arrange for necessary openings in building to allow for admittance of all apparatus.

B. Coordination:
   1. Equipment provided under other Divisions of these specifications.
      a. Motors
      b. Electrically powered equipment
      c. Electrically controlled equipment
      d. Starters, where specified
      e. Variable frequency drives, where specified
      f. Control devices, where specified

g. Temperature Control wiring

2. Provide the following devices required for control of motors or electrical equipment, unless noted otherwise:
   a. Starters
   b. Disconnect devices
   c. Control devices:
      1). Pushbuttons
      2). Pilot lights
      3). Contacts
   d. Conduit, boxes and wiring for Power wiring
   e. Conduit, boxes and wiring for Control wiring, except temperature control wiring
3. Connect and wire equipment complete and ready to operate according to wiring diagrams furnished by various trades.
4. Wire starters or other similar control devices furnished by others.
5. This contractor's drawings and/or specifications show number and hp rating of motors furnished by others, together with their actuating devices. Should any change in size, hp rating, voltage, or means of control be made to any motor or other electrical equipment after Contracts are awarded, Contractor responsible for change shall immediately notify this Contractor. Additional costs due to these changes shall be responsibility of Contractor initiating change.
6. Equipment and wiring shall be selected and installed for conditions in which it will be required to perform. (i.e., general purpose, weatherproof, rain tight, explosion proof, dust tight, or any other special type as required.)
7. Comply with local utility motor starting requirements and provide starters for motors furnished by others as specified herein or under various trade sections of those specifications.

C. Cutting and Patching:
   1. Refer to General Conditions of the Contract and Division 01 - Cutting and Patching.
   2. Perform cutting and patching required for complete installation of systems, unless otherwise noted. Patch and restore work cut or damaged to original condition. This includes openings remaining from removal or relocation of existing system components.
   3. Provide materials required for patching unless otherwise noted.
   4. Do not pierce beams or columns without written permission of Architect/SER and then only as directed. If openings are required through walls or floors where no sleeve has been provided:
      a. Architect/SER approval required.
      b. Floor or wall shall be x-rayed to located reinforcement. Core shall be placed in location where reinforcement will not be cut or damaged.
   5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

D. Housekeeping and Cleanup:
   1. Refer to Division 01 - Closeout Procedures.
   2. As work progresses or as directed by Architect, periodically remove waste materials from building and leave area of work broom clean. Upon completion of work, remove tools, scaffolding, broken and waste materials, etc. from site.

1.10 WARRANTY

A. Refer to Division 01 for general warranty requirements.

B. Refer to technical sections for warranty requirement for each system.
   1. Where no warranty requirements are called out, warrant as called out in Division 01 equipment, materials, and workmanship to be free from defect.

C. Repair, replace, or alter systems or parts of systems found defective at no extra cost to ANL.

D. In any case, wherein fulfilling requirements of any guarantee, if this contractor disturbs any work guaranteed under another contract, this contractor shall restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other contract.

E. Warranty shall include labor, material, and travel time.

PART 2 - PRODUCTS

2.1 PRODUCT SUBSTITUTIONS

A. Refer to Division 01 - Product Requirements.

PART 3 - EXECUTION

3.1 GENERAL

A. Verify elevations and dimensions prior to installation of materials.

3.2 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site under provisions of Division 01.

B. Store and protect products under provisions of Division 01

C. Store in clean, dry space.

D. Maintain factory wrapping or provide cover to protect units from dirt, water, construction debris, and traffic.

E. Handle in accordance with manufacturer’s written instructions.

F. Handle carefully to avoid damage to components, enclosure, and finish. Lift only with lugs provided for the purpose.

G. Provide supplemental heat if required to prevent moisture contamination.

3.3 FLOOR, WALL, ROOF AND CEILING OPENINGS

A. Coordinate location of openings, chases, furred spaces, etc. with appropriate Contractors. Provide sleeves and inserts that are to be built into structure during progress of construction.

B. Remove temporary sleeves, if used to form openings, prior to installation of permanent materials. Utilize minimum 24 ga galvanized sheet metal for permanent sleeves unless otherwise noted.

C. Provide Schedule 40 carbon steel pipe with integral water stop for steel sleeves required below grade or to exterior.

D. Submit to Structural Engineer for review and approval size and location of core-drilled holes prior to execution. Submittal shall include a diagram indicating existing reinforcement within 6” from proposed opening, in all directions. Locate existing reinforcement my non-destructive methods.

E. Submit product data and installation details for penetrations of building structure. Include schedule indicating penetrating materials, (steel conduit, PVC conduit, cables, cable tray, etc.), sizes of each, opening sizes and sealant products intended for use.

F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Section 26 0593 - Electrical Systems Firestopping.

G. Submit complete penetration layout drawings showing openings in building structural members including floor slabs, bearing walls, shear walls, etc. Indicate and locate, by dimension, required openings including those sleeved, formed or core drilled. Submit drawings for approval by SER prior to preparing openings in structural member.

H. Provide 1/2" clearance around penetration openings intended for raceways and cables. Where fire resistant penetrations are required, size openings in accordance with written recommendations of firestopping systems manufacturer.

I. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.

J. Seal non-rated wall openings with urethane caulk.

K. Where penetrations occur through exterior walls into building spaces, use steel sleeves with integral water stop, similar to type "WS" wall sleeves by Thunderline Corporation. Seal annular space between sleeves and pipe with "Link-Seal" modular wall and casing seals by Thunderline Corporation, or sealing system by another manufacturer approved as equal by Engineer. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.

L. Finish and trim penetrations as shown on details and as specified.

M. Provide chrome or nickel plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor’s closets, storage rooms, etc., unless suspended ceilings are specified.

3.4 EQUIPMENT ACCESS

A. Install raceways, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocate raceways or accessories to provide maintenance access at no additional cost to ANL.

B. Install equipment with sufficient maintenance space for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other future or installed equipment.

C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 08 - Access Doors and Frames, unless otherwise indicated. Access doors for equipment shall provide access for servicing, repairs and/or maintenance.

D. Provide necessary coordination and information to the Trade Contractor under Division 08 - Access Doors and Frames. This information shall include required locations, sizes and rough-in dimensions.

E. Provide access doors in walls, chases or inaccessible ceilings for equipment requiring access for servicing, repairs and maintenance, unless otherwise noted. Access frames and doors shall be as manufactured by Milcor, Incorporated, or similar, of style applicable to surface. Provide access doors used in fire-rated construction with UL label. Provide steel, prime-coated access doors in dry locations. Provide stainless steel access doors for use in ceramic tile walls, toilet rooms, locker rooms, and in areas subject to excessive moisture. Provide access doors of sufficient size to allow complete maintenance. Coordinate location of access doors with General Contractor and rough-in equipment accordingly.

F. Locate electrical outlets and equipment to fit details, panels, decorating or finish at space. Architect reserves right to make minor position changes of outlet locations before work has been installed.

G. Verify door swings before installing room light switch boxes. Install boxes on latch side of door unless otherwise noted

3.5 EQUIPMENT SUPPORTS

A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers, etc.

B. Provide steel shell with plug type concrete anchors for attaching equipment to concrete. Plastic, rawhide or anchors using lead are not allowed.

C. Do not support equipment or luminaires from metal roof decking.

3.6 SUPPORT PROTECTION

A. In occupied areas, mechanical and electrical rooms and areas requiring normal maintenance access, guard certain equipment to protect personnel from injury.

B. Provide minimum 1/2" thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.

C. Protect threaded rods or bolts at supporting elements as described above. Trim threaded rods or bolts such that they do not extend beyond supporting element.

3.7 LEAD SHIELDING

A. Wherever installation of this contractor's equipment destroys radiological integrity of wall, floor, or ceiling, this contractor shall be responsible to provide suitable lead shielding to restore that integrity. Coordinate these requirements with General Contractor.

3.8 ELECTRICAL SYSTEMS IDENTIFICATION

A. Refer to Section 26 0553 – Electrical Systems Identification.

3.9 ACCEPTANCE TESTING

A. Contractor shall engage testing and inspection agency to perform acceptance tests. Equipment to be tested is noted as "Testing by Testing Agency" in technical specification sections. Perform in accordance with Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables.

B. When testing is to be witnessed by Architect/Engineer or Inspector, notify them at least 10 days prior to testing date.

C. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or materials as necessary and repeat inspection and test until equipment or systems meet test requirements. Make repairs with new materials.

D. Contractor is responsible for certifying in writing equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria and name and title of person signing test certification documents.

E. Maintain copies of certified test results, including those for any failed tests, at project site. At completion of project, include copies of test records and certifications in O&M Manuals.

3.10 START-UP

A. Systems and equipment shall be started, tested, adjusted, and turned over to ANL ready for operation. This includes "Laboratory-Furnished, Contractor-Installed" (OFCI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.

B. Follow manufacturer's pre-start-up checkout, start-up, trouble shooting and adjustment procedures.

C. Contractor shall provide services of technician/mechanic knowledgeable in start-up and checkout of types of systems and equipment on project.

D. Provide start-up services by manufacturer's representative where specified or where Contractor does not have qualified personnel.

E. Coordinate start-up with all trades.

3.11 COMMISSIONING

A. Perform Commissioning in accordance with the requirements of Section 26 90 00.

3.12 CLEANING

A. Clean systems after installation are complete.

B. Vacuum debris from panelboards, switchboards, motor starter and disconnect switch enclosures, junction boxes and pull boxes two weeks before energization and again prior to completion.

C. Where louvers are provided in switchgear or transformer enclosures, vacuum louvers free of dust and dirt.

D. Clean luminaire lenses and lamps at time of installation and clean lens exteriors just prior to final inspection.

E. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.

End of Section

SECTION 26 05 13.16

MEDIUM-VOLTAGE, SINGLE CONDUCTOR CABLES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 26 – Grounding and Bonding for Electrical Systems

B. Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems

C. Section 26 05 53 – Electrical Systems Identification

D. Section 26 05 93 – Electrical Systems Firestopping

E. Section 26 08 12 – Power Distribution Acceptance Tests

F. Section 26 08 13 – Power Distribution Acceptance Test Tables

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 - General Requirements.

1.3 DESCRIPTION

A. Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

B. Cables are for use in wet or dry locations, underground duct applications.

C. Conductors shall be rated to operate at conductor temperature of 194°F for continuous normal operation, 266°F for emergency overload conditions, and 482°F for short circuit conditions, based on 104°F maximum ambient temperature.

D. Conductor sizes in Section are based on copper wire and only copper wire shall be used.

1.4 REFERENCE STANDARDS

A. AEIC CS 8 – Specification for Extruded Dielectric Shielded Power Cables Rated 5 through 46kV.

B. IEEE 48 – Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5kV through 765kV.

C. IEEE 386 – Standard for Separable Insulated Connector Systems for Power Distribution Systems above 600 V (ANSI).

D. IEEE 404 – Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 – 500000 V (ANSI)

E. IEEE 576 – Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications (ANSI)

F. ICEA S-93-639 – 5-46kV Shielded Power Cables for the Distribution and Transmission of Electrical Energy

G. ICEA S-94-649 – 5-46kV Concentric Neutral Cables Rated 5000 to 46000 Volts

H. ICEA S-97-682 – Utility Shielded Power Cables Rated 5000 to 46000 Volts

I. NFPA 70 – National Electrical Code

J. UL 1072 – Medium-Voltage Power Cable

1.5 SUBMITTALS

A. Product Data: For each type of cable indicated. Include splices and terminations for cable and cable accessories.
   1. Include cable drawings with the following data:
      a. Longitudinal cutback and cross-sectional view of cable.
      b. Identification and structure of cable components.
      c. Dimensions of cable components in English and SI units.

B. Material Certificates: For each cable and accessory type, signed by manufacturer.

C. Manufacturer Testing Certificate: For each type and voltage class of cable indicated.

D. Certified Field Quality Control Test Reports per requirements in Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables for each type and voltage class of cable indicated. Indicate applicable standards compliance. Interpret test results and corrective action taken for compliance with specification requirements.

E. Qualification Data: For testing agency.

F. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation.

G. Installation Guide: Include the following:
   1. Maximum allowable pulling tension (in pounds and newtons)
   2. Minimum allowable bending radius
   3. Recommended pulling compounds
   4. Splicing and termination instructions with diagrams, dimensions, and material lists
   5. Weight per 1,000 ft
   6. Standard "packaging" of reels (i.e., lengths, lagging, banding, etc.)
   7. Reactance and AC resistance (ohms to neutral) of each size and voltage class of cable, both in magnetic and non-magnetic duct, based on 3-1/C cables or 1-3/C cable in one duct.

H. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations of cables, splices, and terminations.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.

1.6 QUALITY ASSURANCE

A. Installer: Engage cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable, having not less than 3 yrs experience as licensed electrician.

B. Regulatory Requirements:
   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

C. Source Limitations: Obtain cables and accessories through one source from single manufacturer.

D. All cables shall be of a single type and configuration. Date of manufacture shall not precede contract date by more than one year.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Coordinate with manufacturer to provide protective covering over cable and reel to prevent damage during shipping, storage, or handling.

B. Store in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Cables:
   1. BICC Cables
   2. Canada Wire
   3. Okonite Company
   4. Southwire Company
   5. Approved equal

B. Cable Splicing and Terminating Products and Accessories:
   1. Raychem Corporation
   2. RTE Components; Cooper Power Systems, Inc.
   3. Thomas & Betts Corporation/Elastimold
   4. 3M; Electrical Products Division
   5. Approved equal

2.2 CABLES

A. Cable Type: MV90

B. Comply with UL 1072, AEIC CS 8, [ICEA S-93-639, and ICEA S-97-682] [ICEA S-94-649]

C. Conductor: Copper

D. Conductor Stranding: Compact round, Concentric lay, Class B

E. Strand Filling: Conductor interstices are filled with impermeable compound

F. Conductor Insulation: Ethylene-propylene-rubber

G. Voltage Rating: 15kV

H. Insulation Thickness: 133 percent insulation level

I. Shielding: Copper tape or Solid copper wires, helically applied over semiconducting insulation shield

J. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket

K. Circuit Identification: color-coded tape (black, red, blue) under the metallic shielding

L. Cable Jacket: Chlorosulfonated polyethylene, CPE. Color: black, unless otherwise designated.

M. Cables utilizing combination insulation shield and jacket are acceptable.

N. Cable lengths shall be supplied with factory-installed, moisture-proof end seals on conductors on each end. Cable seals shall be rubber or plastic caps, and shall prevent moisture from seeping into cable ends.

O. Each cable reel shall be tagged with the following:
   1. Manufacturer
   2. Cable Size
   3. Cable Type
   4. Voltage Class
   5. Manufacture Date
   6. Cable Length
   7. Tolerances
   8. Reel Number
   9. Customer Order No.
   10. Customer Name

P. Surface Marking:
   1. Cables shall be permanently printed (or imprinted) on jacket surface at regular intervals over entire length of cable with the following:
      a. Manufacturer’s name
      b. Conductor size
      c. Voltage class
      d. Insulation type
      e. UL designation

Q. Cables shall be constructed and rated for continuous and intermittent submersion in water and shall be suitable for installation in conduit and underground duct.

R. Cable shield shall be capable of withstanding fault current indicated on drawings for 1/10 second.

2.3 SPLICE KITS

A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for application.

B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include components required for complete splice, with detailed instructions.

1. Combination tape and cold-shrink-rubber sleeve kit with rejacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
2. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
3. Premolded, cold-shrink-rubber, in-line splicing kit.
4. Premolded EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.

2.4 SOLID TERMINATIONS

A. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.
2. Class 1 Terminations: Modular type, furnished as kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules, shield ground strap; and compression-type connector.
3. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.
4. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
5. Class 3 Terminations: Kit with stress cone and compression-type connector.

B. Nonshielded-Cable Terminations: Kit with compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

C. Cable Terminations:

1. Product of one manufacturer and furnished in kit form compatible with insulation and conductor material for cable terminated.

D. Connecting Lugs:

1. Connectors and terminals: Copper with uniform compression over entire contact surface.
2. Terminals on conductors: Solderless terminal lugs.

2.5 ARC-PROOFING MATERIALS

A. Tape for First course on Metal Objects: 10-mil-thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3” thick, compatible with cable jacket.

C. Glass-Cloth Tape: Pressure-sensitive adhesive tape, 1/2" wide.

2.6 FAULT INDICATORS

A. Indicators: Manual reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.7 SOURCE QUALITY CONTROL

A. Test and inspect cables according to Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Pull Conductors: Do not exceed manufacturer's recommended minimum installation temperature, maximum pulling tensions, and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
3. Cut off cable damaged by cable grips or pulling make-ups so as to provide clean, undamaged cable for termination. Continuously record pulling tension during installation.

C. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

D. Support cables in handholes and manholes from walls on heavy-duty, non-metallic cable rack arms, at least 3" above the floor. Support cables with reinforced nylon cradles. Anchor to wall with stainless steel anchor bolts.

1. Install compression connectors with hydraulic compression tool on 600V neutral/ground conductor.

E. Install direct-buried cables on leveled and tamped bed of 3" thick, clean sand. Separate cables crossing other cables or piping by a minimum of 4" of tamped earth. Install permanent markers at ends of cable runs, changes in direction, and buried splices.

F. Install "buried-cable" warning tape per requirements in Section 26 0553 - Electrical Systems Identification.

G. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by longest route from entry to exit and support cables at intervals adequate to prevent sag.

H. Make at least one 360-degree sweep around the inside of each manhole prior to exiting. Fill lowest ducts first, avoid covering or blocking duct entrances and allow space for future cable installation.

I. Cut cable in clean, dry environment. Seal cut ends with waterproof seal immediately after cutting. Maintain a seal during and after pulling.

J. Install cable splices at pull points (accessible locations) and elsewhere as indicated; use standard kits.

K. Install terminations at ends of conductors and seal conductor cable ends with standard kits. Do not install exterior terminations during inclement weather or damp atmospheric conditions.

L. Install stress cones at cable splices and terminations, grounded per cable and connector manufacturer recommendations.

M. Check phase rotation before connections are made to existing circuits. Clearly letter cable terminations. Identify phases with phase designations lettered on terminal boxes and other terminations throughout the system.

N. Install separable insulated-connector components as follows:
   1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected
   2. Portable Feed-Through Accessory: Three
   3. Standoff Insulator: Three

O. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape and/or manufacturer's written instructions, apply arc proofing as follows:
   1. Clean cable sheath.
   2. Wrap metallic cable components with 10-mil pipe-wrapping tape.
   3. Smooth surface contours with electrical insulation putty.
   4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
   5. Band arc-proofing tape with 1-inch-wide bands of half-lapped, adhesive, glass-cloth tape 2" o.c.

P. Seal around cables passing through fire-rated elements according to Section 26 0593 – Electrical Systems Firestopping.

Q. Install fault indicators on each phase where indicated.

R. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware. For grounding requirements, refer to Section 26 0526 – Grounding and Bonding for Electrical Systems.

S. Identify cables according to Section 26 0553 – Electrical Systems Identification.

3.2 FIELD QUALITY CONTROL

A. Perform cable acceptance tests on cable circuits after installing cables and before electrical circuitry has been energized. Splices and terminations required as part of this project are to be completed and acceptance tested as part of cable tests. For cables not spliced or terminated as part of project, ends should be clean, dry and long enough to eliminate leakage from conductor to ground along outer surface of cable.

B. Perform acceptance tests and damage investigations under constant supervision of ANL's representative. Contractor shall coordinate and provide labor, material, equipment, and services necessary to test each completed cable circuit.

C. Remove and replace defective cables and retest as required.

D. Refer to Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables for visual and mechanical inspection and electrical tests. Certify compliance with test parameters.

End of Section

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 19.16 - Manufactured Wiring System

B. Section 26 05 29 - Hangers and Supports for Electrical Systems

C. Section 26 05 33 - Surface Metallic Raceway System

D. Section 26 05 43.16 - Cable in Duct System

E. Section 26 05 53 - Electrical Systems Identification

F. Section 26 05 93 - Electrical Systems Firestopping

G. Section 26 08 12 - Power Distribution Acceptance Tests

H. Section 26 08 13 - Power Distribution Acceptance Test Tables

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes conductors and cables rated 600 V and less, connectors, splices, and terminations rated 600 V and less, sleeves and sleeve seals for cables.

B. Conductor and conduit sizes in these contract documents are based on copper wire, and only copper wire shall be used.

1.4 REFERENCE STANDARDS

A. ASTM A 53/A 53M – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.

B. ASTM B 1 – Standard Specification for Hand-Drawn Copper Wire.

C. ASTM B 8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

D. NEMA WC 3 – Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-19-81).

E. NEMA WC 5 – Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (ICEA S-61-402).

F. NEMA WC 70 – Non-Shielded Power Cable 2000 V or less for the Distribution of Electrical Energy (ICEA S-95-668).

G. NFPA 70 – National Electrical Code.

H. UL 44 – Thermoset-Insulated Wires and Cables.

I. UL 83 – Thermoplastic-Insulated Wires and Cables.

J. UL 486A-486B – Wire Connectors.

K. UL 486C – Splicing Wire Connectors.

L. UL 486D – Standard for Insulated Wire Connector Systems for Underground Use or in Damp or Wet Locations.

M. UL 486E – Standard for Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors.

N. UL 1569 – Standard for Metal-Clad Cables.

1.5 SUBMITTALS

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

B. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation.

C. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

D. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations of components and circuits.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.

1.6 QUALITY ASSURANCE

A. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

B. Wire and cable boxes and reels shall bear the date of manufacture.
   1. Date of manufacture shall not precede contract date by more than one year.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Alcan Products Corporation; Alcan Cable Division

B. American Insulated Wire Corp.; a Leviton Company

C. General Cable Corporation

D. Senator Wire & Cable Company

E. Southwire Company

F. Approved equal

2.2 DESCRIPTION

A. NEMA WC 70; single copper conductor insulated wire; 600 V rated insulation; 194°F maximum operating temperature for dry and wet or damp locations.
   1. Thermoplastic-insulated wires and cables: NEMA WC 5, UL 83; Type THHN, THWN-2.
   2. Thermoset-insulated wires and cables: NEMA WC 3, UL 44; Type XHHW-2.

2.3 REMOTE CONTROL AND SIGNAL CIRCUITS

A. Class 1
   1. Copper conductor, single insulated wire.
   2. Insulation type THHN rated 194°F, 600 V insulation class.
   3. Type XHHW for ambient temperature less than 32°F.
   4. UL 83 listed, ASTM B 1 for solid conductors; ASTM B 8 for stranded conductors.

B. Classes 2 and 3
   1. Copper conductor, multiple twisted conductors covered with an overall non-metallic jacket unless otherwise noted.
   2. Insulation type XLE, rated 221°F 300 V insulation class.
   3. UL listed for use in space in which circuits will be installed.

2.4 CONNECTORS, SPLICES, AND TERMINALS

A. Manufacturers:
   1. AFC Cable Systems, Inc.
   2. Hubbell Power Systems, Inc.
   3. O-Z/Gedney; EGS Electrical Group LLC.
   4. 3M; Electrical Products Division
   5. Tyco Electronics Corp.
   6. Approved equal

B. Description: UL 486A-486B, UL 486C, UL 486D, UL 486E; factory-fabricated connectors, splices, and terminals of size, ampacity rating, material, type, and class for application and service indicated.

2.5 TERMINATIONS

A. Compression set, bolted or screw type lug, or direct to bolted or screw type terminal.

2.6 PLASTIC CABLE TIES

A. Nylon or approved; locking type; metallic ties not permitted.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUCTORS AND CABLES

A. Install conductors in a raceway system, unless otherwise specified or indicated.

B. Install conductors only after:
   1. Building interior is enclosed and weather tight
   2. Mechanical work likely to damage conductors has been completed
   3. Raceway installation is complete and supported

C. Pull conductors into raceway at same time.

D. Neatly train and lace conductors inside boxes, equipment, and panelboards.

E. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

F. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

H. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible. Protect exposed cables from damage.

I. Support cables above accessible ceiling using plastic cable ties to support cables from structure or ceiling suspension system. Do not rest cable on ceiling panels.

J. Support cables and conductors in vertical raceways per requirements in Section 26 0529 - Hangers and Supports for Electrical Systems.

K. Identify and color-code conductors and cables according to Section 26 0553 - Electrical Systems Identification.

L. Wiring at Outlets: Install conductor at each outlet, with minimum 6" of slack.

M. Limit conduit fill to a maximum of 9 current-carrying conductors.

N. Install stranded conductors where conductors terminate in crimp type lugs. Do not place bare stranded conductors directly under screws.

O. Provide separate neutral for each circuit. Shared neutrals are not permitted.

3.2 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid or stranded for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid or stranded for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Minimum conductor sizes shall be as follows:
   1. No. 12 AWG – Branch circuits of any kind.
   2. No. 14 AWG – Remote control and signal systems, fire alarm system.

D. Branch wiring length limitations:
   1. 208Y/120 V circuits over 100 ft in length: Increase wire size one size for each 100 ft of length. Increase conduit size as required.
   2. 480Y/277 V circuits over 150 ft in length: Increase wire size one size for each 150 ft of length. Increase conduit size as required.

3.3 CONDUCTOR INSULATIONS AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHW.

B. Exposed Feeders: Type THHW.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHW.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHW.

E. Exposed Branch Circuits, Including in Crawl Spaces: Type THHN.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: THHN.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN.

H. Motor Circuit Branch Wiring and Associated Control Wiring: Type THHN, rated 90°C for dry and damp locations, single conductors in raceway, stranded.

I. Wiring in Fluorescent Fixture Channels: Type THHN, rated 194°F for dry and damp locations, single conductors.

J. Branch Circuits Single Conductors in Raceway: 194°F rated conductors sized at 167°F rating for connection to equipment and devices.

K. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.4 REMOTE CONTROL AND SIGNAL CIRCUITS

A. Sizing - #16 AWG minimum.

B. Installation:
   1. Install cables in cable tray and cable rings.
   2. Provide protection for exposed cables where subject to damage.
   3. Support cables above accessible ceilings; do not rest on ceiling tiles.

4. Use suitable cable fittings and connectors.

3.5 CONNECTORS, SPLICES, AND TERMINALS

A. Connectors:
1. Except where equipment is furnished with bolted or screw type lug, use compression set pressure connectors with insulating covers. Use compression tools and die compatible with connectors being installed.
2. Use bolt or compression-set type with application of insulating tape, pre-stretched or heat-shrinkable insulating tubing for splices and taps of #8 AWG conductors and larger. Install with hydraulic compression tool.
3. Use pre-insulated “twist-on” connectors with integral spring for splices and taps of #10 AWG conductors and smaller.
4. Tighten electrical connectors and terminals according to manufacturer’s published torque-tightening values. If manufacturer’s torque values are not indicated, use those specified in UL 486A-486B.

B. Splices:
1. Splice wires and cable only in accessible locations such as within junction boxes.
2. Make splices to carry full capacity of conductors with no perceptible temperature rise.
3. Make below-grade splices in manholes and handholes watertight with pre-stretched or heat-shrinkable insulating tubing, or resin-filled insulator.
4. Use electrical tape to build up insulation level equivalent to cable insulation and cover with not less than two half-lapped layers of plastic electrical tape, for joints, taps, and splices of #1 AWG conductors and larger.
5. Plastic snap-on splice insulators are not allowed.
6. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than un-spliced conductors.

C. Terminals:
1. Insulate ends of spare conductors with electrical tape and identify spare circuit number where appropriate.
2. Eye type crimped terminal for removable screw type terminal. Forked torque terminal when screw terminal cannot be removed.
3. Train wires to eliminate fanning of stands, crimp with proper tool and die.
4. Torque screw termination per manufacturer’s recommended values.

3.6 CABLE TIES

A. Neatly bundle conductors and cables together for support. Size cable ties sufficiently to accommodate the multiple cables being supported.

3.7 FIELD QUALITY CONTROL

A. Test 600 volt conductors and cables per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

B. Interpret test results in writing and submit to Engineer.

C. Replace conductors and cables that are found defective, at no expense to Laboratory.

End of Section

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 13.13 - Medium-Voltage Open Conductors

B. Section 26 05 43 - Ducts and Raceways for Electrical Systems

C. Section 26 08 12 - Power Distribution Acceptance Tests

D. Section 26 08 13 - Power Distribution Acceptance Test Tables

E. Section 26 41 13 - Lightning Protection for Structures

F. Section 27 10 00 - Structured Cabling

G. Section 27 11 00 - Communications Equipment Room Fittings

H. Section 27 13 00 - Communications Backbone Cabling

I. Section 27 15 00 - Communications Horizontal Cabling

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes methods and materials for grounding systems and equipment, as required by State Codes, NFPA 70, applicable portions of other NFPA codes, as indicated herein, plus the following special applications:

1. Overhead-lines grounding.
2. Underground distribution grounding.
3. Common ground bonding with lightning protection system.

B. Maximum resistance to ground shall be less than 5 ohms.

C. Refer to Grounding Riser Diagram.

1.4 REFERENCE STANDARDS

A. ANSI J-STD-607-A – Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

B. ASTM B 3 – Specification for Soft or Annealed Copper Wire

C. ASTM B 8 – Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard or Soft

D. ASTM B 33 – Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes

E. IEEE C2 – National Electrical Safety Code (ANSI)

F. IEEE 857 – Standard for Qualifying Permanent Connections Used in Substation Grounding

G. NETA MTS – Maintenance Testing Specifications

H. NFPA 70 – National Electrical Code

I. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance

J. NFPA 780 – Lightning Protection Systems

K. UL 96 – Lightning Protection Components

L. UL 467 – Grounding and Bonding Equipment

1.5 TELECOMMUNICATIONS GROUNDING SYSTEM DEFINITIONS

A. Telecommunications Bonding Backbone (TBB): Conductor that interconnects telecommunications main grounding busbar (TMGB) to telecommunications grounding busbar (TGB).

B. Telecommunications Bonding Conductor: Conductor that interconnects telecommunications bonding infrastructure to building's service equipment (power) ground.

C. Telecommunications Grounding Busbar (TGB): Interface to building telecommunications grounding system, common point of connection for telecommunications system and equipment to ground, and located in telecommunications room or equipment room.

D. Telecommunications Main Grounding Busbar (TMGB): Busbar placed in convenient and accessible location and bonded by means of bonding conductor for telecommunications to building service equipment (power) ground.

E. Irreversible Compression: Permanent mechanical bond between conductors or conductor and connector using mechanical or hydraulic tool

1.6 SUBMITTALS

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

B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:
   1. Test wells
   2. Ground rods
   3. Ground rings
   4. Grounding arrangements and connections for separately derived systems
   5. Grounding for sensitive electronic equipment

C. Field Quality-Control Test Reports:
   1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.
   2. Test reports of resistance to earth. Each test report shall include:
      a. Date of test, soil moisture content, and soil temperature
      b. Test operator
      c. Instrument or other test equipment used

d. Electrode designation or location
e. Ground impedance in ohms
f. Assumptions made - if required

D. Closeout Submittals:
1. Operation and Maintenance Manuals: Include the following:
a. Instructions for periodic testing and inspection of grounding features at ground rings, grounding connections for separately derived systems.
1) Instructions to perform tests to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
2) Include recommended testing intervals.

1.7 QUALITY ASSURANCE

A. Regulatory Requirements:
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70.
2. Comply with UL 467 for grounding and bonding materials and equipment.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store products in clean, dry space. Protect from dirt, fumes, water, corrosive substances, and construction debris.

1.9 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction, insulation color: green.

B. Bare Copper Conductors:
1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4" in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8” wide and 1/16” thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8” wide and 1/16” thick.

C. Bare Grounding Conductor and Conductor Protector for Wood Poles:

1. No. 4 AWG minimum, soft-drawn copper.
2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.

D. Grounding Bus: Horizontal rectangular bars of annealed copper, 1/4” by 2” in cross section.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Compression Connectors: Irreversible type.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad; 3/4” in diameter by 10 ft in length

2.4 TELECOMMUNICATIONS BUSBARS

A. Material: Copper
1. 1/4" thick

B. Pre-drilled
1. 3/8” diameter
2. Hold spacing per ANSI Joint Standard J-STD-607-A
3. Hole pattern shall accommodate two-hole lugs

C. Insulators and one inch stand-off brackets shall electrically isolate busbar from wall or other mounting surface.

D. Provide busbars listed by nationally recognized testing laboratory.

E. Size:
1. Telecommunications Main Ground Busbar (TMGB) - 20" x 4" (minimum)
2. Telecommunications Grounding Busbar (TGB) – 12” x 4” (minimum)

2.5 TELECOMMUNICATIONS GROUNDING CONDUCTORS

A. Material: Stranded copper

B. Provide insulated bonding conductors.
1. Green Jacket or Black Jacket marked with Green Tape or Green adhesive labels per NEC Guidelines.

C. Size:
1. Telecommunications Bonding Conductor (TMGB to Grounding Electrode):
a. No. 3/0 AWG

2. Telecommunications Bonding Backbone (TBB; TMGB to TGB):
   a. No. 3/0 AWG

2.6 TELECOMMUNICATIONS GROUNDING CONNECTIONS

A. Mechanical Connectors:
   1. Connector Body:
      a. High-strength, high-conductivity cast copper alloy.
      b. 2-bolt type.
   2. Bolts, nuts, washers, and lock-washers: Silicon Bronze
      a. Supplied as part of connector body.
      b. Split-bolt connector types are not allowed.
   3. Connector:
      a. Meet or exceed UL 467.
      b. Clearly marked with catalog number, conductor size, and manufacturer.

B. Compression Connectors:
   1. Connector Body: Pure wrought copper.
   2. Conductivity shall be no less than 99% by IACS Standards.
   3. Connector:
      a. Meet or exceed performance requirements of IEEE 837, latest revision.
      b. Factory filled with an oxide-inhibiting compound.
      c. Clearly marked with manufacturer, catalog number, conductor size, and required compression tool settings.
   4. Connection shall be irreversible.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Grounding Bus: Install in electrical and communications rooms
   1. Install bus as indicated on drawings.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor, and connect to horizontal bus.

C. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors
   2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated
   3. Connections to Ground Rods at Test Wells: Bolted connectors
   4. Connections to Structural Steel: Welded connectors

3.2 GROUNDING OVERHEAD LINES

A. Comply with IEEE C2 grounding requirements.

B. Drive ground rods until tops are 12” below finished grade in undisturbed earth.

C. Ground-Rod Connections: Install bolted connectors for underground connections and connections to rods.

D. Lightning Arrester Grounding Conductors: Separate from other grounding conductors.

E. Secondary Neutral and Transformer Enclosure: Interconnect and connect to grounding conductor.

F. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4” will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof PVC sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2” above to 6” below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with transformer and switches by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6” from the foundation.

3.4 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with feeders and branch circuits. Install for each branch circuit neutral originating from panelboards, including lighting circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1. Feeders and branch circuits
   2. Lighting circuits
   3. Receptacle circuits
   4. Single-phase motor and appliance branch circuits
   5. Three-phase motor and appliance branch circuits
   6. Flexible raceway runs
   7. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

C. Duplex receptacles of any amperage: Install separate jumper between grounding terminal on device and metallic box.

D. Size of equipment grounding conductors for branch circuits: As indicated in NEC-70, except minimum size shall be No. 12 AWG.

E. Size of branch panel feeder originating at switchboards/switchgear: As indicated in NEC-70, except in no instance smaller than No. 8 AWG.

F. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, install No. 4 AWG minimum grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4” x 2” 12” grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

G. Install grounding conductor from each standby-emergency generator to grounding electrode system. Provide flexible jumper between base and isolated generator.

H. Install equipment grounding conductor from secondary side of each transformer to grounding electrode system as required for separately derived system.

I. Install grounding for service entrance equipment room consisting of ground bus, ground conductors, and 5/8” x 10’-0” copperweld grounding rods arranged as indicated on drawings.

1. Ground bus shall be horizontal 1/4" x 2” copper bar. Bolt to wall at 10-foot intervals with 1” stand-offs at each bus support.

J. Install grounding conductor to luminaires hanging form conduit swivel hangers.

K. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors to pole base. Grounding Conductor: Same size as phase conductors, but not smaller than No. 10 AWG.

1. Install at each pole or standard a concealed driven 1/2" x 8’-0” ground rod, ground clamp and No. 3 stranded copper conductor concealed and attached to pole and base.

3.5 SEQUENCING, SCHEDULING

A. Permanently attach service grounds before permanent building service is energized.

B. Permanently attach equipment grounds prior to energizing equipment.

3.6 INSTALLATION

A. Connections: Exposed and visible for inspection at all times. Do not install insulation over ground connections.

B. Identify all grounding conductors by system and room number of termination at building grounding electrode point.

C. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

D. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

E. Ground Rods: Install ground rods with the top 1 ft minimum below finished grade.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.

F. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes shall be at least 12" deep, with cover.
   1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

G. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
   3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

H. Grounding and Bonding for Piping:
   1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end. Water pipe, by itself, is not an adequate grounding electrode and must be supplemented by another electrode system. Bond system together.
   2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
   3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

I. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install [tinned copper] bonding jumper to bond across flexible duct connections to achieve continuity.

J. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft apart.

K. Bond steel columns at bases using 4/0 copper conductor to column footing rebar.

L. Make grounding connections on surface that has been cleaned of paint, dirt, oil, etc., so that connections are bare metal to bare metal contact.

M. Make grounding connections tight with UL listed grounding devices, fittings, bushings, etc.

N. Ground Ring: Install a grounding conductor, electrically connected to building structure ground rod and to each, extending around the perimeter of building.
   1. Bury ground ring not less than 24" from building foundation.

O. Concrete-Encased Grounding Electrode: Fabricate according to NFPA 70, using a minimum of 20 ft of bare copper conductor not smaller than No. 4/0 AWG.
   1. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

P. Equipment Grounding Conductor: Terminate in panelboard at green wire ground bus.

Q. Multiple Conductors on Single Lug: Not permitted. Terminate each grounding conductor on its own terminal lug.

R. Flexible Metallic Conduit, Non-Metallic Rigid Conduit, or Liquid Tight Flexible Conduit: Install green wire grounding conductor with phase conductors in conduit.

3.7 TELECOMMUNICATIONS GROUNDING SYSTEM INSTALLATION

A. Provide required elements and miscellaneous hardware necessary to establish Telecommunication Grounding infrastructure as specified.

B. Install products in accordance with manufacturer's instructions.
   1. Install Compression Connectors with compression, tool-and-die system, as recommended by manufacturer of connectors.

C. On the Telecommunications Bonding Conductor and Telecommunications Bonding Backbone (TBB) all connections shall be Compression.

D. Locate TGBs and TMGB per drawings.

E. Telecommunications Bonding Backbone (TBB) shall be continuous and not interrupted by Telecommunications Grounding Busbars (TGB).
   1. TGBs shall be bonded to TBB via tap off of TBB
      a. Exception is "last" TGB on TBB (e.g. furthest from TMGB).

F. Insulate Busbars from their support.

G. Connections shall be bare metal to bare metal contact.
   1. Clean surfaces of paint, dirt, oil, etc.

H. Connections shall be exposed and visible for inspection at all times.
   1. Do not install insulation over ground connections.

I. Terminate each grounding conductor on its own terminal lug.

3.8 FIELD QUALITY CONTROL

A. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
   1. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal at individual ground rods. Make tests at ground rods before any conductors are connected.

B. Test grounding systems per requirements in Section 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

C. Interpret test results in writing and submit to Engineer.

D. Test resistance of each TGB to ground.
   1. Maximum resistance to ground shall be less than 5 Ohms.

E. Inspect completed system by commissioning authority, prior to backfilling.

End of Section

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SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 33 – Raceway and Boxes for Electrical Systems

B. Section 26 12 16 – Dry-Type, Medium-Voltage Transformers

C. Section 26 12 19 – Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers

D. Section 26 13 23 – Medium-Voltage Pad-Mounted Switchgear

E. Section 26 22 00 – Low-Voltage Transformers

F. Section 26 23 00 – Low-Voltage Switchgear

G. Section 26 24 13 – Switchboards

H. Section 26 24 16.13 – Lighting and Appliance Panelboards

I. Section 26 24 16.16 – Distribution Panelboards

J. Section 26 28 16 – Enclosed Switches and Circuit Breakers

K. Section 26 36 23 – Automatic Transfer Switches

L. Section 26 51 00 – Interior Lighting

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes the following:

1. Manufactured hangers and supports for individual raceways and cables, slotted channel and angle systems for multiple conduit runs, and most electrical equipment that is not floor mounted.
2. Construction requirements for concrete housekeeping pads for floor-mounted electrical equipment.

1.4 REFERENCE STANDARDS

A. AWS D1.1/D1.1M – Structural Welding Code-Steel.

B. ASTM A 36/A 36M – Carbon Structural Steel.

C. ASTM A 325 – Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.

D. ASTM A 780 – Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

E. MSS SP-58 – Pipe Hangers and Supports - Materials, Design and Manufacture.

F. MSS SP-69 – Pipe Hangers and Supports - Selection and Application.

G. MFMA-4 – Metal Framing Standards Publication.

H. NECA 1 – Standard Practices for Good Workmanship in Electrical Construction.

I. NECA 101 – Standard for Installing Steel Conduits (Rigid, IMC, EMT).

J. NFPA 70 – National Electrical Code.

K. SSPC-PA 1 – Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Steel slotted support systems.
   2. Nonmetallic slotted support systems.
   3. Raceway and cable supports.
   4. Support for conductors in vertical raceway.
   5. Structural steel for fabricated supports and restraints.
   6. Mounting, anchoring, and attachment components:
      a. Powder-actuated fasteners.
      b. Mechanical-expansion anchors.
      c. Concrete inserts.
      d. Clamps for attachment to structural steel.
      e. Through bolts.
      f. Toggle bolts.
      g. Hanger rods.

B. Shop Drawings: Signed and sealed by an Engineer registered and licensed in the State of Illinois. Include concrete anchors application, size, and placement. Include concrete inserts application, size, loading, and placement. Show fabrications and installation details and include calculations for the following:
   1. Trapeze hangers. Include product data for components.
   2. Steel slotted channel systems. Include product data for components.
   3. Nonmetallic slotted channel systems. Include product data for components.
   4. Fabricated metal equipment support assemblies.

C. Welding certificates.

D. Schedule of hangers and support devices with support spacing.

E. Where loads imposed exceed design superimposed dead loads or hanging loads specified in contract documents, submit for approval to Structural Engineer of Record loads imposed on the primary structural frame. Submittal shall include location, magnitude and direction of imposed loads (basic, unfactored load cases), graphically represented in their appropriate. Detail references indicating the connections applicable at each location shall be noted on the submittal drawings.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, “Structural Welding Code – Steel.”

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of 5 times the applied force.

B. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   1. Finishes
      a. Metallic Coatings:
         1) Factory standard primed, galvanized of electroplated finish and applied according to MFMA-4, for indoor applications.
         2) Hot-dip galvanized after fabrication and applied according to MFMA-4, for outdoor applications.
      b. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4, for corrosive environments.
      c. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
   2. Channel Dimensions: Selected for applicable load criteria.
   3. Manufacturers:
      a. Allied Support Systems; Power-Strut Unit.
      b. Cooper B-Line, Inc.; A division of Cooper Industries.
      c. ERICO International Corporation.
      d. GS Metals Corporation.
      e. Thomas & Betts Corporation.
      f. Unistrut; Tyco International, Ltd.
      g. Wesanco, Inc.
      h. National Pipe Hanger Corporation.
      i. Michigan Hanger Co., Inc.; O-Strut Division.
      j. Approved equal.

C. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16" diameter holes at a maximum of 8" o.c., in at least one surface.
   1. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
   2. Fitting and Accessory Materials: Same as channels and angles.
   3. Rated Strength: Selected to suit applicable load criteria.
   4. Manufacturers:
      a. Allied Support Systems; Power-Strut Unit
      b. Cooper B-Line, Inc.; A division of Cooper Industries
      c. Fabco Plastics Wholesale Limited
      d. Seasafe, Inc.
      e. Approved equal

D. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

E. Raceway and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

F. Support for Conductors in Vertical Raceway: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suite individual conductors or cables supported. Body shall be malleable iron.

G. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

H. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers:
      1) Hilti Inc.
      2) ITW Ramset/Red Head; A division of Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
      4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit
      5) Approved equal
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
   a. Manufacturers:
      1) Cooper B-Line, Inc.; A division of Cooper Industries
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti Inc.
      4) ITW Ramset/Red Head; A division of Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.
      6) Approved equal
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods:
   a. MSS SP-58; threaded steel, with adjusting and lock nuts; electroplated zinc finish.
   b. MSS SP-58; nonmetallic, with adjusting and lock nuts.

2.2 FABRICATED METAL FRAMING EQUIPMENT SUPPORT ASSEMBLIES

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

B. Materials: Comply with requirements in Division 05 Section “Metal Fabrications” for steel shapes and plates; not be lighter than 12 AWG.

C. Finish: Epoxy paint or Electro-galvanized.

D. Manufacturers: Same as in paragraph 2.1.B.3 above.

2.3 CONTINUOUS INSERT CHANNELS

A. Length and support capabilities to be suitable for application.

B. Brackets, inserts and accessories suitable for channel insert selected.

C. Manufacturers:
1. Unistrut; Tyco International, Ltd.
2. Cooper B-Line, Inc.; A division of Cooper Industries
3. Michigan Hanger Co., O-Strut Division
4. Anvil International, Inc.
5. Approved equal

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as [required by] [scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in] NFPA 70.
1. Size steel hanger rods for individual hangers and trapeze supports as indicated in the following schedule. Total weight of equipment shall not exceed limits indicated. If hanging/suspended loads exceed design superimposed dead loads or suspended loads specified in contract document, comply with loads imposed requirement in Part 1 – Submittals.

Maximum Loads (lbs)	Rod Diameter (“)	Maximum Pipe Size With Single Rod
730	3/8	2”
1130	1/2	3”
1818	5/8	5”

2. Size nonmetallic rods for individual hangers and trapeze supports as indicated in the following schedule. Total weight of equipment shall not exceed limits indicated.

Maximum Loads (lbs)	Rod Diameter (“)	Maximum Pipe Size With Single Rod
XXX	XXX	XXX

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25% in future without exceeding specified design load limits.
1. Secure raceways and cables to these supports with 2-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2” and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements, except as specified in paragraphs below.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4” thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4” thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts or Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

F. Do not support raceway by other raceway.

G. Do not support equipment or raceway from metal roof decking or floor decking.

H. Do not impose weight of electrical equipment, raceways, or lighting fixtures on support provided for other trades or systems.

I. Do not support loads from bottom chord member of trusses or open web chord.

J. Suspend hangers by means of hanger rods. Perforated band iron and flat wire (strap iron) are not allowed.

K. Use conduit-mounting pedestals for piping on roof. Install bottom of pedestal flat on roof deck and insulate exterior of pedestal, flush and counter flush.

L. Minimize use of concrete anchors and inserts after concrete pour.

M. Punching, drilling, welding of building structural steel or welding attachment to building structural steel is not allowed, unless approved by structural engineer.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section “Metal Fabrications” for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE HOUSEKEEPING PADS

A. Construct concrete housekeeping pads for all floor-mounted electrical equipment.

B. Dimensions: 3.5” high and not less than 2” larger in both directions than supported equipment, so anchors will be a minimum of 10 bolt diameters from edge of the base.

C. Use 3000-psi 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section “Cast-in-Place Concrete.”

D. Anchor equipment to concrete housekeeping pad.
   1. Place and secure anchorage devices. Use supported equipment manufacturer’s setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Install anchor bolts according to anchor-bolt manufacturer’s written instructions.

E. Coordinate with Architect installation of housekeeping pads on roof.

3.5 PAINTING

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

B. Touchup: Comply with requirements in Division 09 Section “Painting” for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

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SECTION 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems

C. Section 26 05 29 – Hangers and Supports for Electrical Systems

D. Section 26 05 53 – Electrical Systems Identification

E. Section 26 05 93 – Electrical Systems Firestopping

F. Section 26 27 26 – Wiring Devices

G. Section 27 05 53 – Communications Systems Identification

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes raceways, fittings, wireways, wall ducts, indoor service poles, outlet boxes, pull and junction boxes, floor boxes, tap boxes and raceway seals.

1.4 REFERENCE STANDARDS

A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting

B. ANSI C80-1 – Rigid Steel Conduit-Zinc Coated (GRS)

C. ANSI C80-3 – Electrical Metallic Tubing-Zinc Coated (EMT)

D. ANSI C80-5 – Aluminum Rigid Conduit-Zinc Coated (ARC)

E. ANSI C80-6 – Intermediate Metal Conduit-Zinc Coated (IMC)

F. ASTM A 53/A 53M – Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

G. BICSI TDMM – Telecommunications Distribution Methods Manual, Latest Edition

H. NEMA 250 – Enclosures for Electrical Equipment (1000 V Maximum)

I. NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable

J. NEMA OS 1 – Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports

K. NEMA OS 2 – Nonmetallic Outlet Boxes, Device Boxes, Covers, and Box Supports

L. NEMA RN 1 – Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

M. NEMA TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit

N. NEMA TC 3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing

O. NEMA TC 13 – Electrical Nonmetallic Tubing (ENT)

P. NFPA 70 – National Electrical Code

Q. TIA-569-B – Commercial Building Standard for Telecommunications Pathways and Spaces

R. UL 1 – Flexible Metal Conduit

S. UL 6 – Electrical Rigid Metallic Conduit-Steel

T. UL 6A – Electrical Rigid Metallic Conduit-Aluminum and Stainless Steel

U. UL 360 – Liquid-Tight Flexible Steel Conduit

V. UL 514A – Metallic Outlet Boxes

W. UL 514B – Conduit, Tubing, and Cable Fittings

X. UL 514C – Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers

Y. UL 651 – Schedule 40 and 80 Rigid PVC Conduit and Fittings

Z. UL 797 – Electrical Metallic Tubing-Steel

AA. UL 870 – Wireways, Auxiliary Gutters, and Associated Fittings

BB. UL 1242 – Electrical Intermediate Metal Conduit-Steel

CC. UL 1660 – Liquid-Tight Flexible Nonmetallic Conduit

DD. UL 2024 – Optical Fiber and Communication Cable Raceway

1.5 SUBMITTALS

A. Product Data:
   1. Raceways
   2. Fittings
   3. Wireways
   4. Wall ducts
   5. Outlet boxes
   6. Pull and junction boxes
   7. Floor boxes
   8. Tap boxes
   9. Raceway seals

B. Manufacturer’s Installation Instructions:

1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation and installation of product.

C. Closeout Submittals:
1. Project Record Documents:
a. Record actual routing of raceways larger than 2”.
b. Record actual location and mounting heights of wireways, wall ducts, indoor service poles, floor boxes, tap boxes, outlet, pull and junction boxes.
2. Operation and Maintenance Data:
a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

D. Submit for approval to the Structural Engineer of Record (SER) shop drawings locating conduit cast into structural slabs. Spacing and size requirements must be in accordance with 03 3000 and drawings.

E. Submit for approval to the Structural Engineer of Record (SER) shop drawings identifying all embedments into structure, including but not limited to sleeves, box outs, hanger assemblies. Refer to requirements in 03 2000.

1.6 QUALITY ASSURANCE

A. Regulatory Requirements:
1. Comply with NFPA 70.
2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.

B. Protect PVC conduit from sunlight.

C. Comply with manufacturer’s written instructions.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 RIGID METAL CONDUIT (RMC)

A. Rigid Steel Conduit (RSC): ANSI C80.1, UL 6; heavy wall galvanized steel

B. Intermediate Metal Conduit (IMC): ANSI C80.6, UL 1242; thinner wall, galvanized steel

C. Rigid Aluminum Conduit (RAC): ANSI C80.5; heavy wall aluminum

D. PVC coated rigid steel conduit: NEMA RN 1; plastic cap protector caps

E. Fittings (couplings, conduit bodies, connectors and bushings): NEMA FB 1, UL 514B; steel threaded; connectors with double locknuts and steel insulating bushings, thermoplastic insulating bushings for conduits 2” and smaller; conduit bodies cover: stamped cast, with stainless steel screws and neoprene gaskets; PVC coated to match conduit.

F. Fittings Manufacturers: Cooper Crouse-Hinds; Carlon Electric Products; O-Z/Gedney; Appleton; Hubbell; or Approved equal.

2.2 ELECTRICAL METALLIC TUBING (EMT)

A. ANSI C80.3, UL 797; galvanized steel tubing

B. Fittings (couplings, conduit bodies, and connectors): NEMA FB I, UL 514B; steel, watertight gland compression type connectors with double locknuts and insulated throat; conduit bodies cover: stampedsteel, with stainless steel screws and neoprene gaskets. Indentor, drive-on, die-cast or pressure cast fittings not permitted.

C. Fittings Manufacturers: Same as manufacturers listed in 2.1.F.

2.3 FLEXIBLE METAL CONDUIT (FMC)

A. UL 1; interlocked steel

B. Fittings: NEMA FB I, UL 514B; steel

2.4 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. UL 360; interlocked steel, with PVC jacket

B. Fittings: NEMA FB 1, UL 514B; steel

2.5 RIGID NONMETALLIC CONDUIT (RNC)

A. NEMA TC 2, UL 651; Schedule 40 PVC

B. Fittings: NEMA TC 3, UL 651

2.6 ELECTRICAL NONMETALLIC TUBING (ENT)

A. NEMA TC 13; hand-bendable, corrugated PVC conduit

B. Fittings: NEMA TC 3

2.7 LIQUIDTIGHT FLEXIBLE NONMETALLIC CONDUIT (LFNC)

A. UL 1660; flexible conduit with a plastic sheath

B. Fittings: UL 514B

2.8 STAINLESS STEEL CONDUIT

A. UL 6A

B. Type 304

C. Fittings: Threaded

2.9 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY (INNERDUCT)

A. UL 2024; flexible type, approved for general purpose installation

B. Outdoor Innerduct: Smooth outside and ribbed inside

C. Indoor Innerduct: Corrugated

D. Color:
1. General Purpose: Orange
2. Flame-retardant: Orange
3. Riser: Orange
4. Plenum: Orange

E. Manufacturers: Carlon; Pyramid; or approved equal

2.10 METAL WIREWAYS

A. NEMA 250, UL 870; sheet metal troughs with hinged or removable cover, Type 1, unless otherwise indicated.

B. Size: 2-1/2” x 2-1/2”.

C. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mated with wireways as required for complete system.

D. Wireways Covers: Hinged type

E. Knockouts: Manufacturer’s standard

F. Finish: Manufacturer’s standard enamel finish

G. Manufacturers: Hoffman; Square D Co.; or Approved equal.

2.11 OUTLET BOXES

A. Sheet Metal Outlet Boxes: NEMA OS 1, UL 514A; galvanized steel with stamped knockouts.
1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; 1/2" male fixture studs, where required.
2. Concrete Ceiling Boxes: Concrete type

B. Cast-Metal Outlet Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover

C. Nonmetallic Outlet Boxes: NEMA OS 2

D. Gangable type boxes are not allowed.

E. Manufacturers: O-Z/Gedney; Raco; Cooper Crouse-Hinds; or Approved equal.

2.12 OUTLET BOXES FOR COMMUNICATIONS

A. Minimum outlet box size: 4-11/16” square by 2-1/8” deep minimum, with single-gang trim ring, unless otherwise noted on drawings.
1. Total depth of the assembly including the trim ring shall not be less than 2-1/2“.

2.13 PULL AND JUNCTION BOXES

A. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1; galvanized steel

B. Cast-Metal, Pull, and Junction Boxes: NEMA FB 1; galvanized, cast iron with ground flange, gasketed cover and stainless steel cover screws

C. Minimum size: 4” square by 2-1/8” deep for use with 1” conduit and smaller; 4-11/16” square by 2-1/8” deep for use with 1-1/4” conduit and larger

D. Sheet Metal Boxes Larger Than 12” in any direction: Hinged cover or a chain installed between box and cover

E. Field-fabricated boxes not allowed without prior approval of local authority having jurisdiction.

F. Manufacturers: O-Z/Gedney; Raco; Cooper Crouse-Hinds; or Approved equal

2.14 PULL AND JUNCTION BOXES FOR COMMUNICATIONS

A. Size: Per TIA-569-B, unless otherwise noted on drawings.

B. Minimum pull box size: 4-11/16” square by 2-1/8” deep, where pull box is used with raceway(s) smaller than 1-1/4” trade size, unless otherwise noted on drawings.

C. Minimum pull box size, where pull box is used with raceway(s) 1-1/4” trade size or larger:
   1. For straight pull through: Length of at least 8 times trade-size diameter of largest raceway.
   2. For angle and U pulls:
      a. Have distance between each raceway entry inside box and opposite wall of box of at least 6 times trade-size diameter of largest raceway, this distance being increased by sum of trade-size diameters of other raceways on same wall of box; and
      b. Have distance between nearest edges of each raceway entry enclosing same conductor of at least:
         1) Six times trade-size diameter of raceway; or
         2) Six times trade-size diameter of larger raceway if raceways are of different sizes.
      c. For raceway entering wall of pull box opposite to removable cover, have distance from wall to cover of not less than trade-size diameter of largest raceway plus 6 times diameter of largest conductor.

2.15 FLOOR BOXES

A. Metal Floor Boxes: NEMA OS1; cast metal; fully adjustable octagonal; Moisture-proof, with forged brass blank cover with each box and close up covers and/or carpet flanges as required for finished floor.

B. Nonmetallic Floor Boxes: nonadjustable, round

C. Combination Flush Floor Boxes:
   1. Above Grade: Stamped steel, watertight design approved for use on above-grade concrete floor applications, with four independent wiring compartments and capacity for up to four duplex receptacles and/or communication services. The box: fully adjustable providing pre-pour and after-pour adjustment, tunnel compartment, and two receptacle brackets. Conduit knockouts per drawing requirements. Comply with UL 514A and UL 514C scrub water exclusion test for tile, terrazzo, carpet and wood floors.

2. On Grade: Cast iron, watertight design approved for use in on-grade and above-grade concrete floor applications, with four independent wiring compartments and capacity for up to four duplex receptacles and/or communication devices. The box: fully adjustable providing pre-pour and after-pour adjustment, tunnel compartment, and two receptacle brackets. Conduit knockouts per drawing requirements. Comply with UL 514A and UL 514C scrub water exclusion test for tile, terrazzo, carpet and wood floors. Legrand RFB6E-OG or engineering approved equivalent. Silver trim. Contractor to provide all required plates for a complete and working system.
3. Covers: Activation Covers – Die-cast aluminum with textured aluminum finish, and black or brass power-coated paint finishes as selected by the Architect. Cover: flanged or flangeless, as required, with options for tile or carpet inserts, blank covers, or covers with one or two 1” liquid tight conduit openings for furniture feed applications.
4. Communication Modules Mounting Accessories: Complete line of faceplates and bezels provided by floor box manufacturer to facilitate mounting of fiber optic, coaxial, high-performance twisted-pair cabling, and communication devices. Cabling type and faceplate configurations per requirements in Section 27 1500 – Communications Horizontal Cabling. The box shall accommodate workstation connectivity outlets and modular inserts and other system devices.

2.16 TAP BOXES

A. Multi-tap connectors as indicated on drawings.

B. Manufacturers: Ilsco; or Approved equal

2.17 EXPANSION FITTINGS

A. Malleable iron, hot dip galvanized allowing 4” (±2”) raceway movement.

B. Manufacturers: OZ/Gedney AX Series; or equivalent by manufacturer listed in 2.1.F.

2.18 RACEWAY PENETRATION SEALS

A. Thruwall and Floor Seals.

B. Manufacturers: New construction – OZ/Gedney FSK Series; existing construction – OZ/Gedney CSM Series; or equivalent by manufacturer listed in 2.1.F.

2.19 RACEWAY SEALING FITTINGS

A. For one through four conductors: Manufacturers: OZ/Gedney CSB Series; or Approved equal.

B. For greater than four conductors: Manufacturers: OZ/Gedney EYA Series with sealing compound; or Approved equal

C. Low-temperature or hazardous locations: Manufacturers: OZ/Gedney EYA Series with sealing compound; or Approved equal

2.20 CABLE SUPPORTS

A. Manufacturers: OZ/Gedney Type S; or equivalent by manufacturer listed in 2.1.F.

2.21 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends, with integral water stop.

B. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052” or 0.138” thickness and of length to suit application.

C. Integral Water Stop: Manufacturer: Thunderline Corporation; or Approved equal.
   1. High density polyethylene (HDPE). Type Century-Line engineered sleeve with end caps.
   2. Steel. Type WS engineered sleeve.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate with Architect/Engineer by shop drawing submittal size and location of required built-in openings in building structure, including those sleeved, formed or core drilled.

B. Coordinate with Architect/Engineer in writing cutting, removing, or piercing general or mechanical insulation, fire-rated walls, ceilings or steelwork.

C. Verify with Architect/Engineer all surface raceway installations except in mechanical, electrical, and communications rooms.

D. Coordinate with Architect/Engineer by shop drawing submittal exact locations of floor boxes, where shown on drawings, prior to rough-in.

E. Coordinate routing of through-roof conduits.

F. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 26 0593 – Electrical Systems Firestopping.

G. Verify that exterior wall or wet location boxes are gasketed type cast boxes with matching cover.

H. Verify with manufacturer that “touch-up” paint kit and PVC-coating kit are available for use.

3.2 EXAMINATION

A. Examine surfaces to receive raceways and boxes for compliance with installation tolerances and other conditions affecting performance of raceway’s installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. Raceways:
   1. Comply with ANSI/NECA 1 and NFPA 70 for installation requirements applicable to products specified in Part 2 except where requirements on drawings or in this Section are stricter.
   2. Arrange raceways to maintain headroom and present neat appearance.
   3. Raceway routing is shown in approximate locations, unless dimensioned. Route to complete raceway installation before starting conductor installation.
   4. Keep raceways at least 12” away from parallel runs of fuels, steam, hot-water pipes or ductwork. Install horizontal raceway runs above water and steam piping. Install raceways level and square and at proper elevations: 6’-6” minimum headroom, except in exit pathways 7’-0” minimum headroom. Do not block access to junction boxes, mechanical equipment or prevent removal of ceiling panels, etc.
   5. Run raceways concealed in construction to avoid adverse conditions such as heat and moisture, to permit drainage, and to avoid materials and equipment of other trades, except where noted otherwise.

6. Avoid exposed raceway runs. Run raceways exposed where impractical or impossible to conceal or where specific approval is obtained. Run exposed raceways grouped and parallel or perpendicular to construction. Do not route exposed raceways over boilers or other high-temperature machinery or in contact with such equipment. Offset exposed raceways at boxes.
7. Route raceways installed above accessible ceilings parallel or perpendicular to construction.
8. Do not install raceways in structural or topping floor slabs, except where noted on the plans. Install raceway in structural or topping floor slabs, where noted on plans, as follows:
    a. Center raceways in structural slabs clear of reinforcing steel, except where crossing same, and spaced on centers equal or exceeding 3 times the raceway diameter. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement. Space raceways laterally to prevent voids in concrete. Refer to structural drawings and specifications for additional placement information, including typical detail 11/S5.3.2.
    b. Outside diameter of raceway shall not exceed 1/3 the structural slab thickness.
    c. Obtain approval from Engineer for each run of raceway 1” or larger.
    d. Do not install raceways in topping slabs of 2” or less.
    e. Locate raceways to avoid conflict with equipment, door bucks, partitions and other equipment bolted to floor.
    f. Arrange stub-ups so curved portions of bends are not visible above finished slab. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; use flexible metal conduit 6” above the floor. Install threaded plugs flush with floor for future equipment connections.
    g. Change from nonmetallic raceway to RMC or IMC before rising above floor.
    h. Raceways containing emergency circuits: RMC or IMC
9. Cut raceways square using saw or pipecutter.
10. Use hydraulic one-shot raceway bender or factory elbows for bends in raceway larger than 2”, unless sweep elbows required. Bend raceways according to manufacturer’s recommendations. Do not use torches or open flame to aid in bend of PVC conduit.
11. Use raceway fittings compatible with raceways and suitable for use and environment.
12. Provide bushings on all raceways.
13. Raceways minimum sizes:
    a. Minimum raceway size 3/4”, except as noted on drawings.
    b. Minimum home run size: 1”, except as noted on drawings.
    c. Minimum size for flexible metal conduit is 1/2" except 3/8” for luminaires.
    d. Minimum size for liquidtight flexible metal conduit is 1/2".
14. Install empty raceways 2-1/2” and larger with No. 10 galvanized fishwire; install 200 lb nylon pull cord in raceways smaller than 2-1/2”; leave at least 12” of slack at each end of pull wire. Cap raceways at both ends.
15. Feed devices in exterior or load-bearing walls by horizontal conduit runs. Install horizontal conduit runs from device to device on same wall. Do not install horizontal bends in conduit around corners. Feed devices on same wall vertically from above or junction box in suspended ceiling.
16. Raceways Supports:
    a. Independently support or attach raceway system to structural parts of construction. Suspended ceiling systems shall not be considered as structural parts of construction for raceway support. Do not attach raceways to piping system.
    b. Raceway supports for horizontal or vertical single runs:
        1) Hot dipped galvanized heavy-duty sheet steel straps, mineralac clamps or steel slotted support channel system with appropriate components.

2) Spring steel type pressure clamps for raceways 3/4" and smaller.

c. Raceway supports for horizontal and vertical multiple runs:

1) Trapeze-type supports fabricated with steel slotted channel systems with appropriate components.

2) Support horizontal runs with appropriately sized rods.

3) Anchor vertical runs to structure.

4) Spring-steel type pressure clamps for raceways 3/4" and smaller.

d. Vertical raceway runs 1-1/4” and larger passing through floors: Support at each floor with pipe riser clamps.

e. Do not support raceways with wire, perforated pipe straps or plastic tie-wrap. Remove wires used for temporary support.

f. Secure raceways in metal stud walls to prevent rattling.

g. Arrange raceway supports to prevent misalignment during wiring installation.

h. Do not fasten raceways to corrugated metal roof deck.

i. For fasteners and supports, including steel slotted support systems, support devices, support spacing, support of conductors in vertical raceways, and hanger rod size, refer to Section 26 0529 – Hangers and Supports for Electrical Systems and NFPA 70.

17. Identify raceways per requirements in Section 26 0553 – Electrical Systems Identification.

18. Ground raceways per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.

19. Flexible Conduit Connections: Use maximum of 72” of flexible conduit for recessed equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

a. Use LFMC in damp or wet locations subject to severe physical damage.

b. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

20. Install stainless steel raceway clamps, mounting hardware, supports, hangers, etc., when located in “wet” or “wash-down” areas.

21. Communications Raceways:

a. Minimum communications raceway size: 1”, unless otherwise noted on drawings.

b. Install one raceway from each communications outlet box. Horizontal raceway runs between wall outlet boxes are not allowed.

c. Terminate raceway on cable tray.

d. Install insulated bushings on end of each raceway.

e. Use UL listed metallic grounding clamps, when terminating raceway on cable tray.

f. Install with no more than 180 degrees of bends between pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

g. Conduit bend radii (minimum) shall be:

1) Six (6) times internal conduit diameter for conduit 2” or less internal diameter.

2) Ten (10) times internal conduit diameter for conduit greater than 2” internal diameter.

h. Conduit bends shall be smooth, even, and free of kinks or other discontinuities that may have detrimental effects on pulling tension or cable integrity during or after installation.

i. Do not install 90-degree condulets. Install continuous radius sweeps of 45° minimum for 90-degree bends.

j. Do not install continuous sections longer than 100 ft.

k. Install nylon pull cord in empty raceways. Leave at least 12” of slack at each end of pull wire. Cap raceways at both ends.

B. Wireways:

1. Install in accordance with manufacturer's instructions.
2. Use screws, clips and straps to fasten raceway channel to surfaces.
3. Mount plumb and level.
4. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.
5. Supports: Per manufacturer's recommendations.
6. Close ends of raceway channel and unused conduit openings.

C. Boxes:

1. Install boxes to accommodate device indicated by symbol, in conformance with code requirements, number and size of conductors and splices and consistent with type of construction.
2. Install the appropriate cover on surface-mounted boxes:
   a. Raised device covers on 4" square and 4-11/16" boxes and handy box covers on handy boxes, etc.
   b. Device covers that are square drawn or square cut on boxes in block.
   c. Tile covers on boxes in tile.
   d. Round drawn device covers on boxes in lath and plaster walls or dry wall only.
   e. Set front edge of device boxes flush with finished wall surfaces except on walls of non-combustible materials where boxes may have maximum set back of 1/4". Secure flush-mounted box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
3. Set outlet boxes parallel to construction and independently attached to same.
4. Do not install back-to-back and through-the-wall boxes. Install with minimum 6" horizontal separation between closest edges of the boxes. Install with minimum 24" separation in acoustic-rated walls and fire-rated walls.
5. Install multi-ganged boxes where 2 or more devices are in same location, unless otherwise noted.
6. Box Support:
   a. Mount boxes straight.
   b. Install horizontal bracing at top or bottom of box for 3 or more gang device boxes in stud walls.
   c. Install stud support one side, with short piece of stud, for up to 2 gang device boxes.
   d. Do not support boxes with tie-wire.
   e. For one and two gang box support, manufactured bracket supports shall be accepted alternate.
   f. Support boxes independently of raceways.
   g. Install adjustable steel channel fasteners for hung ceiling outlet box.
   h. Install stamped steel bridges to fasten flush-mounted outlet box between studs.
   i. Do not install boxes to ceiling support wires or piping systems.
7. Install partitions in multi-ganged boxes where different types of devices are installed, or devices installed operate at different voltages.
8. Mount boxes in block walls at block joint nearest to indicated height.
9. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.
10. When boxes are installed in fire-resistive walls and partitions, provide 24" horizontal separation between boxes on opposite sides of a wall. In addition, limit penetrations to 16 sq in per penetration and not to exceed a total of 100 sq in per 100 sq ft of wall area.
11. Pull and junction boxes: Install as shown, or as necessary to facilitate pulling of wire and to limit number of bends within code requirements. Install above accessible ceilings and in unfinished areas.
12. Install boxes to be permanently accessible.
13. Do not intermix conductors from more than one system in same junction box or pull box, unless shown or specifically authorized otherwise.

14. Adjust box location up to 10 ft prior to rough-in to accommodate intended purpose.
15. Orient boxes to accommodate wiring devices oriented as specified in Section 26 2726 – Wiring Devices.
16. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6" from ceiling access panel or from removable recessed luminaire.
17. The drawings do not necessarily show every outlet, pull or junction box required. Add all required boxes as necessary.

D. Outlet Boxes for Communications:
   1. Install communications outlet boxes for each communications outlet, or as noted on drawings.

E. Pull and Junction Boxes for Communications:
   1. Position Communications Pull and Junction Boxes:
      a. In any section of conduit longer than 100 ft
      b. Where there are bends totaling more than 180 degrees between pull points or pull boxes
      c. Wherever there is a reverse bend in run
   2. Do not use pull boxes in place of bends on straight section of raceway, unless otherwise shown on drawings.

F. Floor Boxes:
   1. Set metal floor boxes level and flush with finished floor surface.
   2. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
   3. Use cast floor boxes for installations in slab on grade.
   4. Install floor boxes and fittings to preserve fire-resistant rating of slabs and other elements, using materials and methods specified in Section 26 0593 – Electrical Systems Firestopping.
   5. Identify communication outlets per requirements in Section 27 0553 – Communications Systems Identification.

G. Expansion Fittings:
   1. Install raceway expansion and deflection fittings in all raceway runs embedded in or penetrating concrete where movement perpendicular to axis of the raceway may be encountered.
   2. Install raceway expansion fittings complete with bonding jumpers in raceway runs that cross expansion joints in structure and raceway runs mechanically attached to 2 separate structures.
   3. Use couplings and flexible connection made up of 24" length of flexible metal conduit, where EMT runs across expansion joints in ceiling spaces.
   4. Install fitting(s) that provide expansion and contraction for at least 0.0004" per ft of length of straight run per °F of temperature change.
   5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation.

H. Raceway Penetration Seals:
   1. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
   2. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Maintenance of Joint Protection" for materials and installation.
   3. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Section 26 0593 – Electrical Systems Firestopping.

4. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
5. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1” annual clear space between pipe and sleeve for installing mechanical sleeve seals.
6. Underground, Exterior-Wall Penetrations: Install cast-iron “wall pipes” for sleeves. Size sleeves to allow for 1” annual clear space between raceway and sleeve for installing mechanical sleeve seals.
7. Sleeve-Seal Installation: Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
8. Provide chrome- or nickel-plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor’s closets, storage rooms, etc., unless suspended ceilings are specified.
9. Remove temporary sleeves, if used for form wall openings, prior to installation of permanent materials.

I. Raceway Sealing Fittings:
1. Install listed watertight seals to prevent the passage of moisture and water vapor through raceway, where raceway passes from interior to exterior of the building, where raceway passes between areas of different temperatures such as into or out of cold rooms or freezers, where raceway enters room which at any time is subject to low or high temperatures and where raceway enters a room which at any time is subject to internal air pressures above or below normal.
2. Install watertight seals in interior of all raceways passing through building roof, ground floor slab (when the raceway does not extend beyond building footprint), or through outside walls of building above or below grade. Seal on the end inside building, using raceway sealing fittings manufactured for the purpose. Locate fittings at suitable accessible locations. For concealed raceways install each fitting in flush steel box with blank coverplate to match finish of adjacent plates or surfaces.
3. Seal raceways entering or passing through “hazardous (classified) areas” as defined in NFPA 70.

J. Sleeve Installation for Electrical Penetrations:
1. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 26 0593 – Electrical Systems Firestopping.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Rectangular Sleeve Minimum Metal Thickness:
   a. For sleeve cross-section rectangle perimeter less than 50” and no side greater than 16”, thickness shall be 0.052”.
   b. For sleeve cross-section rectangle perimeter equal to, or greater than, 50” and 1 or more sides equal to, or greater than, 16”, thickness shall be 0.138”.
5. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies, unless openings compatible with firestop system used are fabricated during construction of floor or wall.
6. Cut sleeves to length for mounting flush with both surfaces of walls.
7. Extend sleeves installed in floors 2” above finished floor level.
8. Size pipe sleeves to provide annular clear space between sleeve and raceway, unless sleeve seal is to be installed or unless seismic criteria require different clearance.

3.4 APPLICATION

A. Raceway uses permitted and not permitted per NFPA 70 requirements and as described below.

B. Rigid Metal Conduit (RMC) permitted to be installed as follows:
   1. Installations below grade and in or under concrete slabs
   2. All locations except corrosive atmospheres
   3. Hazardous locations
   4. Locations requiring mechanical protection

C. Intermediate Metallic Conduit (IMC) permitted to be installed as follows:
   1. Installation below grade and in or under concrete slabs
   2. All locations, except corrosive atmospheres
   3. Hazardous locations
   4. Locations requiring mechanical protection

D. Electrical Metallic Tubing (EMT) permitted to be installed as follows:
   1. Interior partitions
   2. Above suspended ceilings
   3. In concrete slabs
   4. 6 ft AFF in exposed areas of mechanical equipment rooms
   5. Sizes 2" and smaller except as approved

E. Flexible Metal Conduit (FMC) permitted to be installed as follows:
   1. Use flexible metal conduit not over 4 ft in length for final connections for:
      a. Vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment) in dry locations.
      b. Final connections to recessed luminaires in lengths not to exceed 6 ft.
   2. No flexible metal conduit length restriction when using "Manufactured Wiring Systems."

F. Liquid Tight Flexible Metal Conduit (LFMC) permitted to be installed as follows:
   1. Use liquid tight flexible conduit, not over 4 ft in length, for final connections to:
      a. Vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment) in wet locations.
      b. Instruments and control devices

G. Rigid Nonmetallic Conduit (RNC) permitted to be installed as follows:
   1. Direct burial, concrete encased
   2. Direct burial, in sand fill on bottom and top
   3. Corrosive atmospheres
   4. Use steel elbow in concrete encased runs

H. Optical Fiber/Communication Cable Raceway (Innerduct) permitted to be installed as follows:
   1. To segment conduits, thereby increasing their capacity
   2. As protection to backbone fiber optic cables installed in cable tray or cable support hooks
   3. As protection to fiber optic cable(s) within telecommunications equipment room
   4. As identified on drawings

I. One-half inch raceway permitted:
   1. Between controller and its control or pilot device
   2. Between lighting switch and nearest outlet for luminaire
   3. Control wiring where mounted on equipment where conduit must follow contour of equipment
   4. Protective and signal systems where noted
   5. Where shown on plans

3.5 RACEWAY WIRING METHODS

A. Underground More than 5 ft outside Foundation Wall: Install nonmetallic conduit; install cast metal boxes or nonmetallic handholes.

B. Underground Within 5 ft from Foundation Wall: Install rigid steel conduit.

C. In or Under Slab on Grade: Install nonmetallic conduit.

D. Outdoor Locations, Above Grade: Install galvanized rigid steel conduit.

E. Wet and Damp Locations: Install galvanized rigid steel conduit

F. Concealed Dry Locations: Install electrical metallic tubing.

G. Exposed Dry Locations: Install rigid steel conduit or intermediate metal conduit.

H. Exposed Subject to Damage: Install rigid steel conduit.

3.6 FIELD QUALITY CONTROL

A. Inspect raceway, boxes, indoor service poles, and wireways for physical damage, proper alignment, supports and seismic restraints, where applicable.

B. Replace any damaged component of the raceway system, or install new raceway system.

C. Inspect components, wiring, connections and grounding.

3.7 REPAINTING

A. Repair damage to galvanized finishes with manufacturer-supplied zinc-rich paint kit. Leave remaining paint with Laboratory.

B. Repair damage to PVC or paint finishes with manufacturer-supplied touch-up coating. Leave remaining coating with Laboratory.

C. Wireways, indoor service poles: Remove paint splatters and other marks from surface; touch-up chips, scratches, or marred finished to match original finish using manufacturer-supplied paint kit. Leave remaining paint with Laboratory.

3.8 ADJUSTING

A. Adjust flush-mounted boxes pre-pour and after-pour to be flush with finished materials.

B. Install knockout closures in unused openings in boxes.

C. Align adjacent wall-mounted outlet boxes for switches and similar devices.

D. Adjust outlet boxes to allow luminaires to be positioned as indicated on [drawings] [reflected ceiling plan].

3.9 CLEANING

A. Clean interior and exterior of boxes, wireways, and indoor poles to remove dust, debris and other material.

End of Section

SECTION 26 05 33.13

SURFACE RACEWAY SYSTEM

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems

C. Section 26 05 53 – Electrical Systems Identification

D. Section 26 27 26 – Wiring Devices

E. Section 27 05 53 – Communications Systems Identification

F. Section 27 15 00 – Communications Horizontal Cabling

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes surface metallic raceway system for branch circuits, data network, voice, video, and other low-voltage wiring.

B. Surface raceway system shall consist of raceway bases, appropriate fittings, and device mounting plates necessary for a complete installation.

C. The lengths of the raceways shown on drawings are illustrative and diagrammatic only and are not accurate. Raceways shall be provided completely installed to match lengths of cabinets and shelving as indicated on (laboratory) casework shop drawings. Receptacle circuits shall be pre-wired.

D. Non metal surface raceway only permitted in Environmental Rooms. Refer to Section 13 0340.

1.4 REFERENCE STANDARDS

A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting.

B. NFPA 70 – National Electrical Code.

C. UL 5 - Surface Metal Raceways and Fittings.

D. UL 5A - Nonmetallic Surface Raceways and Fittings.

E. UL 94 – Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.5 SUBMITTALS

A. Product Data: Catalog cuts of components.

B. Shop Drawings:
   1. Complete layout, with locations of raceway components.
   2. Grounding, branch circuiting, and wiring including locations of service entrances.
   3. Receptacle types, manufacturers, and spacing.
   4. Receptacle labeling with proper voltage, phase, circuit and panelboard designations, as indicated on drawings.
   5. Communication faceplate types, manufacturers and labeling.

C. Samples of receptacle labeling.

D. Sample of communications outlet labeling.

E. Sample section of raceway mounted with receptacles and communications outlets configured with applicable connector types.

F. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

G. Closeout Submittals:
   1. Project Record Documents
      a. Record actual locations of surface raceways with receptacle types, locations and circuits identified.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.6 QUALITY ASSURANCE

A. Obtain surface raceways from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

B. Comply with manufacturer's written instructions.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Metallic Raceways:
1. Mono-Systems
2. Post Glover
3. Square D
4. Wiremold

B. Nonmetallic Raceways:
1. Carlon
2. Hubbell
3. Mono Systems
4. Panduit
5. Wiremold

2.2 FABRICATION

A. UL 5, UL 5A, as applicable

B. Fabrication:
1. Steel.
2. Suitable for use in dry interior locations only.
3. Two-piece with base and snap-on cover.
4. Base: two compartments with moveable dividers and cover plate, as indicated on drawings.
5. Two-compartment raceway with separate cover for each compartment.
6. Two compartments - same size as Wiremold Isoduct ALA 4800 Series
7. Covers with cutouts for device plates as shown on drawings.
8. 6” and 12” long device plates with flange to overlap joint of adjacent cover.

C. Prewired Raceways:
1. Wiring devices factory installed, wired, and covers labeled with panel number and circuit number, voltage, phase, and amperes, as identified on drawings, per requirements in Sections 26 0519 – Low-Voltage Electrical Power Conductors and Cables and 26 2726 – Wiring Devices.
2. Raceway sections with 12” pigtails at feed locations, in 2 ft minimum length and customized to match length shown on drawings.
3. Equivalent distance between receptacles; number of receptacles per length of raceway as shown on drawings.
4. Factory installed, NFPA 70 sized, grounding conductors, per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.
5. Raceway covers with communication outlets factory mounted.
6. Wiring devices on top and communication outlets on bottom.

D. Material:
1. Steel Raceways: Galvanized steel, minimum thickness 0.040”.
2. Aluminum Raceways: Alloy 6063-T5 extruded aluminum, minimum thickness 0.060”.

3. Nonmetallic Raceways: Nonflammable self-extinguishing, tested to UL94, V-0.
4. Fittings: Same material and metal thickness as linear raceway components.

E. Finish:
1. Steel Raceway :
   a. Electrostatically painted, refer to Architectural specifications for color.
2. Nonmetallic Raceways: refer to Architectural specifications for color.
3. Fittings: Color to match linear raceway components.

F. Accessories:
1. Fittings: Available as standard accessories, including external corner units, internal corner units, flat units, blank end units, internal and external elbows, coupling for joining raceway sections, and device mounting brackets and plates.
2. Wire Clips: One for every 2 linear ft of indicated raceway configuration.
3. Corner elbows and tee fittings, to maintain 2” cable bend radius that meets requirements for communications pathways and specifications for fiber optic, coaxial, and high-performance twisted-pair cabling.
4. Device Mounting Bracket s and Plates: Plastic device mounting brackets and trim plates allowing installation of indicated wiring devices, and communications outlets horizontally in raceways; trim cover sized to overlap device cut-out in raceway, concealing seams; finished to match linear raceway components; plastic compatible with UL 94; brackets and plates, to match raceway width, and with device mounting holes.

G. Communications Outlets and Accessories:
1. Cabling Type: Per requirements in Section 27 1000 – Structured Cabling and Section 27 1500 – Communications Horizontal Cabling.
2. Mounting faceplates and bezels: Faceplates configuration per requirements in Section 27 1000 Structured Cabling and Section 27 1500 – Communications Horizontal Cabling.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate cover plate openings with the wiring devices contained within.

B. Coordinate cover plate openings with the communications outlets contained within, to provide for one opening for each communication symbol shown on drawings in Division 27. Coordinate device plate sizes (single-gang or two-gang) to accept communication faceplate types specified in Section 27 1000 – Structured Cabling and Section 27 1500 – Communications Horizontal Cabling.

C. Verify with manufacturer that ‘touch-up’ paint kit is available for repainting.

D. Coordinate surface raceways installation with laboratory casework shop drawings to match lengths of cabinets and shelving.

E. Verify location of raceways with architectural interior elevation drawings.

3.2 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.

B. If substrate preparation is the responsibility of another installer, notify Architect/Engineer of unsatisfactory preparation before proceeding.

3.3 INSTALLATION

A. Install in accordance with ANSI/NECA 1 and manufacturer's instructions.

B. Install flathead screws, clips and straps to fasten surface raceways to substrates, ensuring they are permanently and mechanically anchored. Double-sided adhesive is not acceptable. Mount plumb and level. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.

C. Install wiring devices and communications outlets of type, quantity and spacing as indicated on drawings.

D. Mount raceways on wall and casework parallel to or at right angles to structure and casework.

E. Feed raceways mounted on walls, casework, or modular casework from a backbox through a wall box connector. Determine point of feed in field and complete wiring connections.

F. Install a chase nipple extension between outlet box on wall and raceway when raceway mounted to support channel for modular casework.

G. Maintain ground continuity throughout entire raceway length per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.

H. Do not field cut prewired raceways.

I. Install appropriate backbox extension rings where raceway is mounted to steel slotted channel or by some other method, stood off from wall.

J. Raceway receptacle faceplates shall be labeled with adhesive labels with 1/4" high lettering, per requirements in Section 26 0553 – Electrical Systems Identification, indicating receptacle voltage, phase, and amperage (i.e., 120V, 1-phase, 20A) at top of receptacle, and panel and circuit designation (i.e., NLP-D2-2/12) at bottom of receptacle, in accordance with requirements in Section 26 0553 – Electrical Systems Identification, for 15A, 20A and 30A receptacles.

K. Reinforce each cover section for every 30A receptacle in raceway with two 4-40 Phillips counter-sunk steel screws attached to enclosure near top and bottom of receptacle.

L. Identify communication outlets per requirements in Section 27 0553 – Communications Systems Identification.

M. Raceway base shall be secured using screws. Securing with double-sided adhesive is not acceptable.

3.4 FIELD QUALITY CONTROL

A. Inspect surface raceways for physical damage and proper alignment.

B. Inspect components, wiring, connections, installation, and grounding.

3.5 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.

B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Laboratory.

3.6 CLEANING

A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

End of Section

SECTION 26 05 36

CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 00 00 - General Electrical Requirements

B. Section 26 05 26 - Grounding and Bonding

C. Section 26 05 29 - Hangers and Supports for Electrical Systems

D. Section 26 05 33 - Raceway and Boxes for Electrical Systems

E. Section 26 05 93 - Electrical System Firestopping

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Provide complete cable tray system including straight tray sections, fittings such as horizontal elbows, vertical risers, crosses, tees, wyes, reducers and coupling accessories, splice plates, and cable tray supports to support cable systems in locations as indicated on drawings.

B. Cable tray system is intended to carry telephone, data and communications cable only; power wiring and fire alarm system cabling not allowed.

1.4 REFERENCE STANDARDS

A. ASTM A 123 - Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and forged Steel Shapes, Plates, Bars, and Strip.

B. ASTM A 446 - Specification for Zinc-Coated (Galvanized) by Hot-Dip Process, Structural (Physical) Quality.

C. ASTM A 525 - Specification for Steel Sheet, Zinc-Coated Galvanized by Hot Dip Process.

D. ASTM A 607 - Specification for Steel Sheet and Strip, Hot-rolled and Cold-Rolled, High Strength, Low Alloy Columbium or Vanadium.

E. ASTM B 633 - Specification for Electro-deposited Coatings of Zinc on Iron and Steel.

F. NEMA VE 1 - Metal Cable Tray Systems.

1.5 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section.

B. Submit as-built drawings showing floor plan location, elevation changes, and conduit drops.

C. Where loads imposed exceed design superimposed dead loads or hanging loads specified in contract documents, submit for approval to Structural Engineer of Record loads imposed on the primary structural frame. Submittal shall include location, magnitude and direction of imposed loads (basic, unfactored load cases), graphically represented in their appropriate locations on a copy of the Contract Document structural framing plans or elevations as appropriate. Detail references indicating the connections applicable at each location shall be noted on the submittal drawings.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable Manufacturers: B-Line, Chalfant, Globe, Mono Systems, Inc.

2.2 FABRICATION AND MANUFACTURER

A. Materials of Construction:
   1. Materials shall be adequately protected against corrosion or made of corrosion resistant material.

B. Tray system shall not present sharp edges, burrs or projections injurious to wiring. Upper flanges shall be rolled out and downward for safety.

C. Tray System shall be Wire Mesh Type
   1. Description: Continuous, rigid, welded steel wire mesh cable management system.
   2. Wire Mesh to be welded at all intersections. Along runway sides (flanges) each wire end shall be rounded to provide for safe handling and protect cables from damage during installation.
   3. Material: Carbon steel wire, ASTM A 510, Grade 1008. Wire welded, bent, and surface treated after manufacture.
   4. Finish: Electro-Plated Zinc Galvanizing per ASTM B 633, Type III, SC-1 <u>or</u> Electro-plated yellow zinc dichromate in accordance with ASTM B633 SC2.
   5. Dimensions:
      a. Inside Width: As indicated on Project Drawings.
      b. Loading depth (NEMA VE-1): 4” minimum
      c. Inside radius of fittings: Field fabricated in accordance with manufacturer's instructions from straight sections. Radius of fitting (minimum) to approximate 12-inch radius if using trough-type cable tray.
   6. Hardware, including splice connectors and support components furnished by manufacturer.
   7. Tray shall have a UL classification for tray to be used as an equipment grounding conductor.

D. Cable tray shall be designed to support volume capacity of the cables and provide safe mechanical support for spans up to 8 feet (2.4 meters) on center. Tested load deflection data is available either in accordance with NEMA VE1 or IEC 61537 standards.

E. Support System to be part of a system incorporating mechanisms for Wall Installation, Trapeze or side support mounting to ceilings.

F. Provide splice plates with straight sections and fittings.
   1. Splice plates shall be the bolted type made as indicated below for each tray type.
   2. Splice plate construction shall be such that a splice may be located anywhere within the support span without diminishing rated loading capacity of the cable tray.

3. Splice plate construction shall be designed to permit splice to be located at any point within support span without diminishing cable tray rated loading capacity.
4. No more than one cable tray splice shall be placed between support spans.

G. Special accessories shall be furnished as required to protect, support, and install a cable tray system.
1. Provide complete cable tray system including straight tray sections, fittings such as horizontal elbows, vertical risers, crosses, tees, wyes, reducers and coupling accessories, splice plates and cable tray supports to support cable systems in locations as indicated on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Tray system shall be accessible, with sufficient space provided about cable trays to permit side access for installation and maintenance of cables.

B. Provide blind end plates for trays that dead end.

C. Provide full-width dropouts where cables exit from tray.

D. Join cable tray system sections at ends using manufacturer prefabricated splice plates.

E. Provide prefabricated expansion splice plates at intervals of 48 ft in straight runs and where cable tray systems cross building expansion joints.

F. Provide minimum of 1 expansion splice plate in straight runs, which exceed 12 ft for tray installations in exterior areas.

G. Support cable tray system utilizing trapeze hangers from building or other structural steel members, angle brackets from vertical structural steel members, upright angle brackets on pipe racks, or directly upon horizontal structural steel members of the building or pipe racks.

H. Size, anchor, and space supports to sustain weight of cable tray system, cable, and tubes that are to be installed into cable tray, and 200 lbs excess on any individual ladder rung or section, with safety factor of 1.5 minimum when supported as simple span and tested per NEMA requirements. Load and safety factors are applicable to both, rung or section and side rails.

I. Calculate supports based on 60 lb load of cables and tubes.

J. Total vertical tray deflection shall not exceed 1-1/2" between supports.

K. Include dynamic loads in calculations for outside area installations.

L. Make intersections, bends, and tees, using fittings of same type and model series as straight run sections.

M. Place barriers to obtain size of each raceway as noted on drawings.

N. Cable tray systems shall be electrically continuous.

O. Connect each cable tray system subassembly to building ground system using grounding clamps and grounding conductors. Provide 3.0 ohm maximum resistance to building ground connection.

P. Copper grounding conductors shall not be installed on aluminum tray systems.

Q. Cable tray shall not be connected to instrumentation grounding system.

R. Cable tray system components shall not be flame-cut or arc-cut. Make cuts using a saw and remove burrs.

S. Nicks and scratches and ends of cut sections with galvanized coatings shall be coated with approved galvanizing coating after tray installation.

T. Conductor Installation:
   1. Provide metallic grounding conduit clamps to attach conduits to cable tray system.
   2. Provide bushings on conduit ends where cables enter conduit to protect insulation.
   3. Make multiple drops at ends of sections using manufacturer prefabricated ladder drops.
   4. Provide plastic prefabricated closure straps (tie-wrap type) of black or opaque color for securing cables in cable tray system. Ensure that cables are not cut by applying these straps too tightly or by fastening strapped grouping to another strapped grouping.
   5. Cut strap ends on opposite side of rung from cables or tubes except where back of rung is inaccessible.
   6. Strap cables larger than #1/0 to cable tray rungs every 3 to 4 ft in horizontal runs to prevent movement due to fault current magnetic field forces.
   7. Cables smaller than #1/0 shall not be fastened to cable tray rungs in horizontal runs. Strapping is to be kept to minimum.
   8. Strap vertical runs as required, to prevent sagging of cables.
   9. Provide sufficient slack in cables to allow for unequal expansion coefficients of cable tray and cables. This requirement is in addition to slack required at cable tray expansion joints.

End of Section

SECTION 26 0539

UNDERFLOOR RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 03 3000 - Cast-In-Place Concrete

B. Section 05 3100 - Steel Decking

C. Section 26 0000 - General Electrical Requirements

D. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables

E. Section 26 0526 - Grounding and Bonding for Electrical Systems

F. Section 26 0533 - Raceway and Boxes for Electrical Systems

G. Section 26 0553 - Electrical Systems Identification

H. Section 26 0593 - Electrical Systems Firestopping

I. Section 26 2726 - Wiring Devices

J. Section 27 0553 - Communications Systems Identification

K. Section 27 1500 - Communications Horizontal Cabling

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Provide under floor raceway systems including materials, accessories, and wiring, except cellular floor will be furnished and installed by others.

B. Provide complete under floor duct - Trench duct raceway system, including materials, accessories and wiring, in locations as indicated on drawings.

C. Provide Trench duct in locations, widths, and barriered into power and communications compartments as indicated on drawings.

D. Under floor system shall provide underfloor distribution for electrical and communications services.

1.4 REFERENCE STANDARDS

A. UL209 – UL Standard for Safety for Cellular Metal Floor Electrical Raceways and Fittings

B. UL 884 - Underfloor Raceways and Fittings

1.5 SUBMITTALS

A. Product Data: catalog cuts of components.

B. Shop Drawings:
   1. Complete layout, with locations of raceway components.
   2. Grounding, branch circuiting, and wiring including locations of service entrances.
   3. Receptacle types, manufacturers, and spacing.
   4. Receptacle labeling with proper voltage, phase, circuit and panelboard designations, as indicated on drawings.
   5. Communication faceplate types, manufacturers and labeling.

C. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use. Include instructions for storage, handling, protection, examination, preparation, installation, and start-up of product.

D. Closeout Submittals:
   1. Project Record Documents
      a. Record actual locations of raceways with service types, locations and circuits identified.
   2. Operation and Maintenance Data:
      a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.6 QUALITY ASSURANCE

A. Obtain surface raceways from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

B. Comply with manufacturer’s written instructions.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Cellular Metal Underfloor Raceway Systems
   1. H. H. Robertson
   2. Walker Systems, Inc. [CorDeck]

2.2 CELLULAR METAL UNDERFLOOR RACEWAY SYSTEM

A. System shall consist of Service Raceway, Trench Duct, Preset Inserts and Activation kits,
   1. Service Raceway shall consist of hollow spaces formed when a steel sheet, cold formed into a fluted panel, is joined by spot welding to a flat metal bottom sheet and is provided as factory assembled structural steel floor deck system. One Service Raceway shall be a cell that encloses a single space with a longitudinal axis parallel to that of the steel deck unit.
   2. Trench Duct shall be a transverse wire raceway that provides access to predetermined Service Raceways (cells) of a cellular metal floor system by the premises wiring system.

B. Service Raceway formed by the cellular metal decking system shall be provided under Division 05
   1. Material and Fabrication: Steel, factory assembled:
      a. Cells shall be contiguous and maintain complete isolation from adjacent cells.
      b. Cross-Sectional Area of Cells:
         1). Power cells: [4.2 sq in] [4.3 sq in] [8.5 sq in] minimum
         2). Communication system cells: [8 sq in] [11 sq in] [18 sq in] minimum
   2. Provide factory punched holes into each cell wall, of size and arrangement require for preset insert location spacing required and Trench Duct or Junction Box locations.

C. Preset Inserts: Rectangular-shaped metal housing assemblies arranged to provide electrical system outlet access to each cell designated for service raceway use. Inserts provided throughout the entire length of each such raceway.
   1. List for application.
   2. Spacing [as indicated on drawings] [24” on center].
   3. Housing and connecting provisions:
      a. [Flush][recessed]
      b. Triple-system service fitting.
   4. Include mounting and connecting provisions for surface, single- or multiple-system service fitting.
   5. Include connecting provisions for wiring-extension service fitting to feed wall outlets.
   6. Each insert shall be equipped with a disposable cover plate arranged for installation with top 1/8” below surface of concrete. Arrange insert to receive flush-, recessed-, or wiring-extension service fitting to replace disposable top.

D. After-Set Inserts: Assemblies to tap raceways and floor cells through holes core-drilled in floor shall not be utilized for new construction.

E. Service Fittings and Activations:
   1. Provide activations as indicated on plans.
      a. Recessed with flange

b. Recessed without flange
c. Flush partition with flange
d. Recessed partition without flange

2. Activation kits shall provide triple service access and shall be UL Listed and Classified.
3. Activation kits shall allow 2 separate receptacle boxes and faceplates to accommodate duplex receptacles and communication device mounting brackets.
4. Activation to include metal covers.
   a. Supporting wire egress shall be provided with center located, gasketed opening.
   b. Flangeless for under carpet and tile applications.
   c. Include flange for mounting to floor.
   d. Blank or provide area for flooring insert.
   e. Cover for feeding furniture partition shall be provided two 1” factory punched holes.
   f. Provide an adjustment range spanning 3/4”.
5. Recessed:
   a. Modular fittings that include covers, provisions for receptacles and outlets, and associated device plates for indicated services
   b. Flush handhole covers with brushed-aluminum trim, recessed to suit floor finish material

PART 3 - EXECUTION

3.1 INSTALLATION

A. Metal raceway shall be electrically continuous and bonded for proper grounding.

B. Raceway Support: Support at intervals not exceeding 5 ft or in accordance with manufacturer's installation sheets.

C. Accessories: Provide accessories as required for complete installation, including insulated bushings and inserts where required by manufacturer.

D. Unused Openings: Close unused raceway openings using manufacturers recommended accessories.

E. Coordinate architectural and electrical drawings for dimensions prior to installation. If conflicts exist between drawings, consult the Architect/Engineer.

F. Install distribution raceway system and accessories in accordance with manufacturer's installation instructions, and as specified.

G. Align installations parallel to, or at right angles with building walls and level to finished floor.

H. Cellular metal floor systems: Coordinate cellular metal floor systems construction and installation with structural.

I. Cellular metal floor systems: Inspect cellular raceway steel deck and verify units are level and are placed in straight lines through the entire length of the cells. Provide metal cover over abutting joints between steel deck units exceeding 1/2”. Repair all sharp edges, burrs, or protrusions or replace steel deck unit.

J. Cellular metal floor systems: Apply self adhesive tape to abutting end joints at cellular floor units immediately after they have been secured in place. Seal ends of cellular metal unit to prevent ingress of dirt

water or concrete. Seal raceways, cells, and inserts to prevent water, concrete, or foreign matter from entering raceways before and during pouring slab or placing fill

K. Cellular metal floor system: Provide bonding lug on steel deck and bond to Header Duct sections with #4 bare copper ground wire between. Bond all steel decks with active cells to premises grounding system

L. Marker screw caps shall be used at locations including: adjacent to junction boxes, on each side of permanent walls, at each end run of duct, and on both sides of change of direction of duct.

M. After concrete has hardened, trenchduct shall be swabbed out and dried where moisture occurs.

N. Openings shall be covered during construction.

O. Vacuum duct free of dirt, mortar, concrete, and other debris.

P. Cap or plug boxes, openings, and open raceway ends.

Q. Inserts shall be factory capped.

R. Each run shall be marked at each end with marking screws.

3.2 CLEANING AND PROTECTION

A. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer.

B. Protect raceways and boxes until acceptance.

End of Section

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SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 03 30 00 - Cast-In-Place Concrete

B. Section 26 05 26 - Grounding and Bonding for Electrical Systems

C. Section 26 05 33 - Raceway and Boxes for Electrical Systems

D. Section 26 05 43.13 - Excavation and Backfill

E. Section 26 05 43.19 - Manholes and Hardware

F. Section 26 05 53 - Electrical Systems Identification

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes conduits, ducts, and duct accessories for [direct buried] [and] [concrete encased] for underground distribution for electrical power and communications.

B. The terms duct and duct bank, as used in this Section, are defined as follows:
   1. Duct: A single underground conduit, encased in concrete or direct buried.
   2. Duct Bank: Two or more ducts run together.

1.4 REFERENCE STANDARDS

A. ANSI C2 – National Electrical Safety Code

B. ANSI C80.1 – Rigid Steel Conduit-Zinc Coated (GRC)

C. ASTM F512 – Specification for Smooth-Wall Poly (Vinyl Chloride) (PVC) Conduits and Fittings for Underground Installation

D. NEMA TC2 – Electrical Polyvinylchloride (PVC) Conduit

E. NEMA TC3 – PVC Fittings for Use with Rigid PVC Conduit and Tubing

F. NEMA TC6&8 – PVC Plastic Utilities Duct for Underground Installation

G. NEMA TC9 – Fittings for PVC Plastic Utility Duct for Underground Installation

H. NFPA 70 – National Electrical Code

I. UL 651 – Schedule 40 and 80 Rigid PVC Conduit

J. UL 651A – Type EB and A Rigid PVC Conduit and HDPE Conduit

K. UL E53373 – Underground Fiber Reinforced Epoxy Conduit (FRE)

L. ULG – Electrical Rigid Metallic Conduit-Steel

1.5 SUBMITTALS

A. Product data for the following:
1. Duct bank materials, including spacers and miscellaneous components
2. Ducts and conduits and their accessories, including elbows, end bells, bushings, seals, bends, fittings, plugs, pull tape, and solvent cement
3. Warning tape
4. Warning plank

B. Manufacturer's Installation Instructions:
1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

C. Closeout Submittals:
1. Project Record Documents:
a. Record actual routing of conduits and duct banks.
2. Operation and Maintenance Data:
a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.6 QUALITY ASSURANCE

A. Regulatory Requirements:
1. Comply with NFPA 70
2. Comply with ANSI C2
3. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.

B. Deliver ducts to project site with end capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 CONDUITS

A. Rigid Steel Conduit (RSC): ANSI C80.1, UL 6, heavy wall, hot dipped, galvanized steel.

B. Rigid Nonmetallic Conduit (RNC): NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer, complying with NEMA TC 3 and UL 651, listed for underground use, concrete encased.

C. Size:
   1. 4” nominal for voltages below 600 V and communications
   2. 5” nominal for voltages above 600 V

D. Duct Accessories:
   1. Duct Spacers: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling. Horizontal and vertical locking separation between ducts as shown on drawings.
   2. Elbows: Material to match conduit; minimum bend radius of 36”.
   3. Bell Ends: Manufactured bell ends of appropriate sizes at each end of conduit; pre-manufactured system for PVC with conduit seals, provisions for roughing into the concrete pour and waste stops, when entering a new building or a new manhole.
   4. Bushings: Groundable steel bushings of appropriate sizes on all metal conduits where bell ends are not used; pre-manufactured system for PVC with conduit seals, provisions for roughing into concrete pour and water stops, when entering a new or existing building, a new or existing handhole, or pull box.
   5. Seals: Mechanical interlocking assembly seal of modular synthetic rubber links properly sized to fit the pipe and tightened in place, in accordance with manufacturer’s instructions, when entering an existing building or handhole, pull box below grade and concrete shall be core drilled for the appropriate size conduit and seal.
   6. Plugs: Closure plugs or caps of same material as conduit at ends of unused sections.
   7. Pull Tape: Nylon pull tape with measurement markings in uniform lengths in each empty duct.

E. Grounding:
   1. Steel grounding bushings, where bell ends are not used.
   2. Bonding fitting with bonding strap on steel conduit with end bells.

F. Warning Tape: Underground line warning tape specified in Section 26 0553 - Electrical Systems Identification.

G. Concrete Working Plank: Nominal 12” x 24” x 3” in size, manufactured from 6000 psi concrete.
   1. Color: Red dye for electrical duct bank and yellow dye for communications duct bank added to concrete during batching.
   2. Label: 2” high, 3/8” deep letters with word “ELECTRIC” marked on plank.

H. Solvent Cement: Recommended by conduit manufacturer.

I. Multicell Raceway Systems: An outer shell with pre-lubricated inner ducts preinstalled. A typical assembly: 4” shell with 4 cells of 1-1/2” inner ducts. The outer shell: Available in bullet-resistant fiberglass, galvanized steel, and electrical metallic tubing; manufactured for direct burial and concrete encasement installation methods.

J. PVC and High Density Polyethylene (HDPE) Bundles: For installation in large-bore steel casings. The bundles: Assembled with bore spacers to keep conduits aligned within the casing.

K. Preassembled Multiduct Kits: Communication ducts, assembled with duct spacers, ready to lay in trenches for direct burial or encasement. A typical preassembled kit: Four 1-1/2" ducts in 20-foot lengths.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate layout and installation of ducts with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct bank entrances into handholes, pull boxes, pad-mounted switchgear, pad-mounted transformer, with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect. For manholes and handholes construction, refer to Section 26 0543.19 – Manholes and Hardware.

C. Adjust the depth of electrical utilities to avoid existing utilities with no change to contract price.

D. Utility Coordination: When duct lines are being constructed for use by a utility serving the project, consult with them for duct size and quantity, minimum bending radii, maximum distance between pulling points, grounding details, termination arrangement, and other criteria.

E. Duct Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
   1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
   2. Drawings shall be signed and sealed by a qualified professional engineer.

3.2 EXISTING UTILITIES

A. The existing utilities shown on contract drawings have been plotted from available records. No guarantee is made as to accuracy of locations indicated, and is shown for the benefit of Contractor.

B. Protect shown, visible and located utilities from damage. Promptly repair all active shown, visible and located utilities damaged by construction. This repair shall be made solely at the expense of the Contractor.

C. Coordinate with ANL all existing utility lines prior to commencing work.

3.3 PROJECT CONDITIONS

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by ANL or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify ANL no fewer than 2 weeks in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without ANL's written permission.

3.4 DUCT INSTALLATION

A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with minimum radius of 48”, both horizontally and vertically, at other locations, unless otherwise indicated. All 90-degree sweeps with radius 10 ft or less: Rigid steel conduit.

C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer’s written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane. Do not use conduit that requires the use of couplings for straight runs. Use acceptable PVC terminal adapters when joining PVC conduit to metallic fittings or rigid metal conduit.

D. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10” o.c. for 5-inch ducts, and vary proportionately for other duct sizes.

1. Begin change from regular spacing to end-bell spacing 10 ft from the end bell without reducing duct line slope and without forming a trap in the line.
2. Direct Buried Duct Banks: Install an expansion and deflection fitting in each conduit in area of disturbed earth adjacent to manhole or handhole.
3. Concrete Enclosed Duct Banks: Install watertight expansion fitting in each conduit, with internal bonding jumper to allow for 3/4" movement in any direction.
4. Grout end bells into structure walls from both sides to provide watertight entrances.

E. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 5 ft outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 26 0533 - Raceway and Boxes for Electrical Systems.

F. Expansion Fittings: Provide suitable expansion fittings or other suitable means to compensate for expansion and contraction for raceways crossing expansion joints in structures or concrete slabs between two adjacent structures and between a duct bank and structure. Provide for the high rate of thermal expansion and contraction of PVC conduit by providing PVC expansion joints as recommended by manufacturer and as required. Refer to structural drawings for location of expansion joints in structures.

G. Sealing: Provide temporary closure at termination of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand minimum of 15 psig hydrostatic pressure. Provide watertight entrance sealing device where an underground conduit enters a structure through a concrete roof or membrane waterproofed wall or floor.

H. Fire Stops: Provide fire stop openings around electrical penetrations to maintain fire-resistance rating, where underground raceways penetrate fire-rated walls or floors.

I. Pulling Cord: Install 100-lbf-test nylon cord in ducts, including spares. Identify with tags at each end and at any intermediate pull point the origin and destination of each spare duct. [Where a duct has been identified with a name and numbers in the Raceway identification table, use that name on the tag in lieu of origin and destination.] Provide a removable permanent cap over each end of each spare duct.

J. Concrete Encased Ducts: Support ducts on duct spacers.

1. Spacer Installation: Space spacers close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 ft of duct. Secure spacers to earth and to ducts to prevent floating during concreting. Stagger spacers approximately 6” between tiers. Tie entire assembly together using tie wires and reinforcing steel. Install base and intermediate spacers at every coupling point of each duct line for a separation horizontally and vertically per NEC.
2. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
   a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to

manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.

b. Terminate each pour in a vertical plane if more than one pour is necessary, and install 3/4" reinforcing rod dowels extending 18" into concrete on both sides of joint near corners of envelope. Obtain Architect's approval for the number and location of dowels.

3. Pouring Concrete: Space concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct bank application.
4. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing bars and ties without forming conductive or magnetic loops around ducts or duct groups. Size reinforcing bars and wire ties as indicated on drawings. Provide rebars with minimum of 2" of concrete on sides, top and bottom. Reinforcing bars shown in sections are required throughout.
5. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms of materials and in a manner acceptable to Architect.
6. Minimum Space between Ducts: 3" between ducts and exterior envelope wall, 2" between ducts for like services, and 4" between power and signal ducts.
7. Depth: Install top of duct bank at least 24" below finished grade in areas not subject to deliberate traffic, and at least 30" below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
8. Maintain a grade of at least 4" per 100 ft, either from one manhole or pull box to the next, or from a high point between them, depending on surface contour.
9. Warning Tape: Bury warning tape approximately 12" above all concrete-encased ducts and duct banks. Align tape parallel to and within 3" of the centerline of duct bank. Provide an additional warning tape for each 12" increment of duct bank width over a nominal 18". Space additional tapes 12" apart, horizontally.
10. Place duct banks on an undisturbed soil base if possible. Where concrete encased duct bank is installed over an extensive area of disturbed earth such that within the periphery of a building, provide a separate concrete base under the duct bank to ensure stability of raceways during installation. Allow this base to set before duct bank is installed.

K. Stub-Ups:

1. Use manufactured PVC duct elbows for stub-ups at poles and equipment and at building entrances through floor, unless otherwise indicated. Extend concrete encasement throughout length of the elbow. Concrete encasement applies to concreted encased ducts.
2. Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

a. Couple steel conduits to ducts with adapters designed for this purpose, and encase couplings with 3" of concrete. Concrete encasement applies to concrete encased ducts.

b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete pads, extend steel conduit horizontally a minimum of 5 ft from edge of equipment pad or foundation. Encase in concrete for concrete encased ducts. Install insulated grounding bushings on terminations at equipment.

L. Arrangement and Routing:

1. Arrange multiple duct runs substantially in accordance with details shown on drawings. Locate underground ducts where indicated on drawings and grade to the elevations shown on civil drawings.
2. Make minor changes in location or cross-section as necessary to avoid obstructions or conflicts. Where duct runs cannot be installed substantially as shown because of conditions not discoverable prior to

digging of trenches, refer the condition to the Construction Manager for written instructions before further work is done.

3. Maintain a 12-inch minimum vertical separation between ducts and other systems at crossings where other utility piping systems are encountered or being installed along a raceway route. Maintain a 12-inch minimum separation between ducts and other systems in parallel runs. Do not place ducts over valves or couplings in other piping systems. Refer conflicts with these requirements to the Construction Manager for written instructions before further work is done.
4. Provide markers at grade to indicate direction of underground conduits provided under this contract. Provide markers consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction. Provide markers at all bends and at intervals not exceeding 100 ft in straight runs. Use markers made of sheet bronze not less than 1/4" thick embedded in and secured to the top of concrete posts. User markers not less than 10” long and 3/4” wide and marked ELECTRIC CABLES in letters 1/4" high incised into the bronze to a depth of 3/32”.
5. Enter manholes and structures with ducts at right angles.

3.5 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Cables Over 600V: RNC, NEMA Type ECP-40-PVC, in concrete encased duct bank, unless otherwise indicated.

B. Ducts for Electrical Feeders 600V and Less: RNC, NEMA Type EPC-40-PVC, in concrete encased duct bank, unless otherwise indicated.

C. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-40-PVC, in concrete encased duct bank, unless otherwise indicated.

D. Underground Ducts Crossing Paved Paths, Walks and Driveways, Roadways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.6 EARTHWORK

A. Excavation and Backfill: Comply with Section 26 0543.13 - Excavation and Backfill, do not use heavy-duty, hydraulic-operated compaction equipment.

3.7 CONCRETE

A. Concrete: 3000 psi, 28-day strength, complying with Division 03 – Concrete, where concrete encased.

3.8 GROUNDING

A. Ground underground ducts according to Section 26 0526 - Grounding and Bonding for Electrical Systems.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts.
   2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80% fill of duct. If obstructions are indicated, remove obstructions and retest.

B. Preparation for pulling in conductors:
   1. Do not install crushed or deformed raceways. Avoid traps in raceways where possible. Take care to prevent the lodging of plaster, concrete, dirt, or trash in raceways, boxes, fittings, and equipment during the course of construction. Make raceways entirely free of obstructions or replace them. Ream all raceways, remove burrs, and clean raceway interior before introducing conductors or pull wires.

2. Immediately after installation, plug or cap all raceway ends with watertight and dust-tight seals until the time for pulling in conductors.

C. Do not backfill underground direct buried and concrete encased ducts until the Architect has inspected them. Notify Architect 24 hrs in advance of duct concrete pour, or backfill of direct buried ducts.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

End of Section

SECTION 26 05 43.13

EXCAVATION AND BACKFILL

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 43 - Underground Ducts and Raceways for Electrical Systems

B. Section 31 20 00 - Earth Moving

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section lists methods and materials for trench excavation and backfill for electrical and communications conduits in duct banks. Refer to Section 26 0543 – Underground Ducts and Raceways for Electrical Systems.

1.4 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

B. Excavation: Removal of material encountered above sub-grade elevations and to lines and dimensions indicated.

C. Duct: A single underground conduit encased in concrete or direct buried.

D. Duct Bank: Two or more ducts run together.

E. Fill: Soil materials used to raise existing grades.

F. Sub-grade: Surface or elevation remaining after completing excavation, or top surface of fill or backfill immediately below subbase, drainage fill, or topsoil materials.

G. Utilities: On-site underground ducts and duct banks as well as underground services within buildings.

1.5 SUBMITTALS

A. Submit list of materials to be used for backfill.

1.6 QUALITY ASSURANCE

A. Pre-excavation Conference: Conduct conference at project site to comply with requirements in Division 01 Section “Project Coordination.”

PART 2 - PRODUCTS

2.1 FILL MATERIAL

A. Type 1 Fill:
   1. Material from excavation separated from materials, which do not compact by tamping and rolling. No stones larger than 3” and no building, organic, or corrosive or frozen materials and no lumps larger than 6”.

B. Type 2 Fill:
   1. Sand or gravel materials with none larger than 2" and of that portion passing the #4 sieve less the 5% to pass #200 sieve.

C. Type 3 Fill:
   1. Gravel of rounded to sub-angular shape, screened, which will pass 3/4" sieve and retained on #4 sieve.

D. Type 4 Fill:
   1. Pit run rock or gravel with maximum stone size of 1".

E. Type 5 Fill:
   1. Pea gravel, screened, which will pass 3/8" sieve and retained on #4 sieve.

2.2 CRUSHED ROCK

A. Crushed Rock: 1-1/4” minus, unless smaller is required for bedding material.

2.3 SAND

A. Sand: Clean and washed building sand.

2.4 TOPSOIL

A. Topsoil: Equal in quality to that removed.

2.5 SOD

A. New Sod: Mature, densely rooted grass free of weeds and objectionable grasses.

2.6 PLANTS

A. Plants: Obtained from a commercial nursery and be similar to those replaced.

PART 3 - EXECUTION

3.1 PREPARATION

A. Obtain Laboratory digging permit.

B. Establish grade lines and locations of roadways and sidewalks, grade beams, and pill caps. Provide necessary stakes and batter boards.

C. Verify elevations of existing utilities prior to excavation for new ducts.

D. Verify locations of vaults and manholes with civil drawings

E. Coordinate excavation and backfill with Section 31 2000 – Earth Moving.

3.2 EXCAVATION

A. Provide excavation for underground work, including ducts, vaults, manholes, handholes, pull boxes, unless otherwise shown or specified. Lay duct in open trench, except when Architect gives written permission for tunneling.

B. Excavate trench to 24" wider than duct or duct bank dimensions and minimum of 3" below bottom of duct.

C. Include clearing, tree removal, grubbing, pavement removal, substructure removal such as walls, footings, and piers, and all incidental work such as tunneling, sheet piling, shoring, underpinning, pumping, bailing, and transportation. Coordinate excavation extending beyond construction limits with Construction Manager and ANL.

D. Do not provide blasting on this project without written permission of Architect and ANL.

E. Remove all excess excavation material from site, unless directed otherwise.

F. Over excavate 3” and fill with 3” of sand, where trench bottom is rock, or rocky, or contains debris larger than 1”, or material with sharp edges.

G. Perform all crossings of concrete or asphalt after surface material has been saw cut to required width and removed.

H. Conform to utility company requirements for excavation and vault installation in addition to contract document requirements where excavations are for installing utility company’s ducts and vaults.

3.3 ROCK EXCAVATION

A. Use mechanical methods to remove rock in trenches for underground ducts.

B. Refer to Geotechnical Report available from Architect/Engineer for data on rock.

C. Include rock excavation in the Bid, unless otherwise indicated.

3.4 INSTALLATION

A. Keep underground ducts to proper line and grade and sealed to prevent entrance of animals or foreign matter.

B. Provide bracing and sheet piling as necessary to support trenches. Comply with Local Regulations, applicable provisions of OSHA Regulations on trenching, or with provisions of “Manual of Accident Prevention in Construction” published by Associated General Contractors of America.

C. Do not lay duct in water.

D. Keep trench free from water until duct joint material has hardened and concrete encasement is in place.

E. Do not increase the contract cost due to presence of ground water in soil or necessity of sheet piling or bracing trenches. Adjust contract cost when sheet piling is left in place, on written order of ANL.

F. Do not remove sheet piling until trench is substantially backfilled. Cut off sheet piling left in place not less than 2 ft below new, finished grade.

G. Place underground ducts on 3” compacted bedding of sand. Shape bedding for clearance for joints and fittings, tamped in place and graded evenly to ensure uniform bearing for the full length of duct. Do not support duct by blocking, planking or mounding of bedding material.

H. Install lines passing under foundations with minimum of 3” clearance to concrete and ensure there is no disturbance of bearing soil.

3.5 BACKFILL

A. Backfill around ducts by hand to depth of 12" above top of duct with Type 3 or 5 fill in 6" layers. Compact backfill thoroughly with compactor of suitable weight or with approved mechanical tamper. Do not use flooding or jetting with water.

B. Place backfill from 12" above duct to elevation of subgrade in layers not exceeding 8" in depth with specified Type 3, 4 or 5 fill.

C. Backfill from 12" above duct to sub-grade with Type 2, 3, or 4 fill, when excavating through areas which are to become walks, roads, driveways or parking areas of concrete, bituminous or exposed gravel surfacing or such areas are existing to remain. Backfill in 12" layers and compact with mechanical means to density 95% modified proctor.

D. Conform excavation, duct laying, backfilling, grading and surfacing, as herein specified, when excavation occurs on public property or areas beyond the property line. Comply with additional requirements for public utility or other authorities. Check with each utility and incorporate cost of any additional requirements in base bid.

E. Backfill around vaults and handholes to be free of debris larger than 1-3/4” in all directions to 1 ft from vault.

F. Provide 6” of pea gravel or sand bedding for vaults and handholes larger than 3’-0” x 3’-0”. For handholes smaller than 3’-0’ x 3’-0”, provide 3” pea gravel or sand.

G. Other backfill shall be free of debris larger than 6” in diameter.

H. Place backfill material so as to obtain a minimum degree of compaction of 95% of maximum density at optimum moisture content. Moisten backfill material as required to obtain proper compaction.

I. Broken pavement, concrete, sod, roots, and debris shall not be used for backfill.

3.6 DEWATERING

A. Provide, operate, and maintain all pumps or other dewatering equipment required for control of water in trenches and excavations for electrical and communications site work during the entire construction period.

3.7 SHORING

A. Provide as required by trenching and excavating to secure site work. Comply with applicable safety regulations.

3.8 FINISHING

A. On completion of trenching and backfilling operations, restore grades to original elevation or to new sub-grade elevation.

B. Replace surfaces to existing conditions when trenching is through existing areas or beyond construction limits.

C. Use 6” of topsoil and sod to match existing elevations in landscaped areas or as otherwise approved by Landscape Architect.

3.9 SURFACE FINISHING

A. Refinish every disturbed surface to its original condition.

B. Replace planted materials not surviving 90 days after contract acceptance at Contractor’s own expense.

C. Return after 1 year and re-fill, compact and refinish settled areas to grade.

3.10 CARE OF PLANTS AND TREES

A. Remove and safely store plants and trees with trunks smaller than 6” diameter prior to commencing site work. Avoid trees larger than 6” diameter when so indicated on drawings. Replace plants and trees upon completion of site work.

End of Section

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SECTION 26 05 43.19

MANHOLES AND HARDWARE

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 03 30 00 – Cast-in-Place Concrete

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems

C. Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems

D. Section 26 05 43.13 – Excavation and Backfill

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes underground utility structures: manholes, handholes, pull boxes and accessories for power and communication cable systems.

1.4 REFERENCED STANDARDS

A. AASHTO HB 17 – Standard Specifications for Highway Bridges

B. ANSI C2 – National Electrical Safety Code

C. ASTM A 48/A 48M – Specification for Gray Iron Castings

D. ASTM C 270 – Specification for Mortar for Unit Masonry

E. ASTM C 387 – Specification for Packaged, Dry, Combined Materials for Mortar and Concrete

F. ASTM C 858 – Specification for Underground Precast Concrete Utility Structures

G. ASTM C 891 – Standard Practice for Installation of Underground Precast Concrete Utility Structures

H. ASTM C 1037 – Practice for Inspection of Underground Precast Concrete Utility Structures

I. ASTM E 329 – Standard Specification for Agencies Engaged in Construction Inspection and/or Testing

J. ISO 9000 – Quality Management

K. ISO 10012 – Measurement Management System

L. NFPA 70 – National Electrical Code

M. SCTE 77 – Specification for Underground Enclosure Integrity

N. BICSI – Customer-ANL Outside Plant Design Manual

1.5 SUBMITTALS

A. Product Data:
   1. Accessories for underground utility structures.

B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
   1. Duct entry provisions, including locations and duct sizes.
   2. Reinforcement details
   3. Frame and cover design and manhole frame support rings.
   4. Ladder details
   5. Grounding details
   6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
   7. Joint details

C. Shop Drawings for Factory-Fabricated Handholes and Pull Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
   1. Duct entry provisions, including locations and duct sizes.
   2. Cover design
   3. Grounding details
   4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

D. Product Certificates: For concrete and steel used in precast concrete manholes and handholes as required by ASTM C 858.

E. Qualification Data: For professional engineer and testing agency.

F. Source quality-control test reports.

G. Field quality-control test reports.
   1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

H. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

I. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual location of underground utility structures.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.6 QUALITY ASSURANCE

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

B. Comply with ANSI C2

C. Comply with NFPA 70

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store underground utility structures at project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

B. Life and support precast concrete units only at designated lifting or supporting points.

1.8 GUARANTEE (WARRANTY)

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general guarantee requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 PRECAST CONCRETE MANHOLES

A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom. Frame and cover shall form top of enclosure and shall have load rating consistent with that of manhole.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carder Concrete Products
   2. Christy Concrete Products
   3. Elmhurst-Chicago Stone Co
   4. Oldcastle Precast Group
   5. Riverton Concrete Products; a division of Cretex Companies, Inc
   6. Utility Concrete Products, LLC
   7. Utility Vault Co
   8. Wausau Tile, Inc

C. Comply with ASTM C 858 and with interlocking mating sections, complete with accessories, hardware, and features.
   1. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12” vertically and horizontally to accommodate alignment variations.
      a. Windows: Located not less than 6” from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
      b. Window opening: Cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
      c. Window openings: Framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
   2. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
      a. Type and size: Fittings matched to duct or conduit to be terminated.
      b. Fittings: Aligned with elevations of approaching ducts and located near interior corners of manholes to facilitate racking of cable.

D. Concrete Knockout Panels: 1-1/2 to 2” thick, for future conduit entrance and sleeve for ground rod.

E. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the groundwater level at grade.

2.2 PRECAST CONCRETE HANDHOLES AND PULL BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Carder Concrete Products
   2. Christy Concrete Products
   3. Elmhurst-Chicago Stone Co
   4. Oldcastle Precast Group
   5. Riverton Concrete Products; a division of Cretex Companies, Inc
   6. Utility Concrete Products, LLC
   7. Utility Vault Co
   8. Wausau Tile, Inc

B. Comply with ASTM C 858 for design and manufacturing processes.

C. Structural Load Ratings: As specified in Part 3 “Underground Enclosure Application.”

D. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or pull box.
   1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
   2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
   3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
      a. Cover Hinges: Concealed, with hold-open ratchet assembly
      b. Cover Handle: Recessed
   4. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.
      a. Cover Hinges: Concealed, with hold-open ratchet assembly
      b. Cover Handle: Recessed
   5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   6. Cover Legend: Molded lettering, “ELECTRIC” or “TELEPHONE”.
   7. Configuration: Units shall be designed for flush burial and have integral closed bottom, unless otherwise indicated.
   8. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12” vertically and horizontally to accommodate alignment variations.
      a. Windows: Located no less than 6” from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
      b. Window opening: Cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie-in to concrete envelopes of ductbanks.

c. Window openings: Framed with at least two additional NO. 4 steel reinforcing bars in concrete around each opening.

9. Duct Entrances in Handhole Walls:
   a. Type and size: Fittings matched to duct or conduit to be terminated.
   b. Fittings: Aligned with elevations of approaching ducts and located near interior corners of handholes to facilitate racking of cable.
10. Handholes 12” wide by 24” long and larger: Inserts for cable racks and pulling-in irons installed before concrete is poured.

2.3 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

PART 3 - EXECUTION

3.1 UNDERGROUND ENCLOSURE APPLICATION

A. Manholes: Precast concrete:
   1. Manholes Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
   2. Manholes Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.2 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND PULL BOXES

A. Precast Concrete Manhole and Handhole Installation
   1. Comply with ASTM C 891, unless otherwise indicated.
   2. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
   3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1” sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
   4. Concrete: 5000 psi, 28-day strength, complying with Division 3 – Concrete.

B. Elevations:
   1. Roof: Install with rooftop at least 15” below finished grade.
   2. Frame: In paved areas and trafficways, set frames flush with finished grade. Set other rames 1” above finished grade.
   3. Install handholes with bottom below the frost line.
   4. Handhole Covers: In paved areas and trafficways set surface flush with finished grade. Set covers of other handholes 1” above finished grade.
   5. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Access: Circular opening in manhole roof; sized to match cover size.
   1. Fixed Ladders: Offset access opening from centerlines to align with ladder.
   2. Install chimney, constructed of precast concrete collars and rings, to support frame and cover and to connect cover with roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.

D. Waterproofing: Apply waterproofing to exterior surfaces after concrete has cured at least 3 days. Waterproofing materials and installation are specified in Division 07 Section. After ducts have been

connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior chimneys after mortar has cured at least 3 days.

E. Damp-proofing: Apply damp-proofing to exterior surfaces of after concrete has cured at least 3 days. Damp-proofing materials and installation are specified in Division 7 Section "Bituminous Damp-proofing." After ducts have been connected and grouted, and before backfilling, damp-proof joints and connections and touch up abrasions and scars. Damp-proof exterior of chimneys after mortar has cured at least 3 days.

F. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms and insulators as required for installation and support of cables and conductors and as indicated.

G. Field-Installed Bolting Anchors: Do not drill deeper than 3-7/8" for manholes and 2" for handholes, for anchor bolts installed in the field. Use a minimum of 2 anchors for each cable stanchion.

H. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.

I. Pack and smooth non-shrink grout at all rough edges around duct.

3.3 GROUNDING

A. Ground utility structures according to Section 26 05 26 - Grounding and Bonding for Electrical Systems.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:
   1. Demonstrate capability and compliance with requirements on completion of installation of underground utility structures.
   2. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26 - Grounding and Bonding for Electrical Systems.

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Interpret test results in writing and submit to Engineer.

3.5 CLEANING

A. Clean internal surfaces of manholes, including sump and remove foreign material, after completing the installation of all devices, equipment, cables and terminations.

B. Remove water from manholes. If manholes continue to fill up with water, Contractor shall pump them regularly until the source of water has been detected and corrected.

End of Section

SECTION 26 05 53

ELECTRICAL SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 13.16 – Medium-Voltage Cable

B. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

C. Section 26 05 33 – Raceways and Boxes for Electrical Systems

D. Section 26 05 43 – Underground Ducts and Raceways for Electrical Systems

E. Section 26 05 73 – Overcurrent Protective Device Coordination Study

F. Section 26 09 13 – Electrical Power Monitoring and Control

G. Section 26 09 23 – Lighting Control Devices

H. Section 26 22 00 – Low-Voltage Transformers

I. Section 26 23 00 – Low-Voltage Switchgear

J. Section 26 24 16.13 – Lighting and Appliance Panelboards

K. Section 26 24 16.16 – Distribution Panelboards

L. Section 26 27 26 – Wiring Devices

M. Section 26 28 16 – Enclosed Switches and Circuit Breakers

N. Section 26 36 23 – Automatic Transfer Switches

O. Section 26 43 00 – Transient Voltage Suppression

P. Section 28 31 13 – Detection and Alarm Systems

Q. Section 28 31 16 – Multiplexed Fire Detection and Alarm Systems

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 - General Requirements.

1.3 DESCRIPTION

A. Section includes the following:
   1. Identification for raceway and metal-clad cable.
   2. Identification for conductors and communication and control cable.
   3. Underground-line warning tape.
   4. Warning labels and signs.
   5. Instruction signs and posted drawings.

6. Equipment identification nameplates.
7. Wiring devices identification.
8. Miscellaneous identification products.

B. Refer to the respective Division 26 Sections, and Sections in other Divisions that specify electrical components, for additional electrical identification requirements.

1.4 REFERENCE STANDARDS

A. ANSI A13.1 – Scheme for the Identification of Piping Systems

B. ANSI C2 – National Electrical Safety Code

C. ANSI Z535.4 – National Standards for Product Safety Signs and Labels

D. 29 CFR – Labor, Part 1910 – Occupational Safety and Health Standards, Section 1910.145 – Specifications for Accident Prevention Signs and Tags

E. NFPA 70 – National Electrical Code

1.5 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Nameplate Schedule: Prior to making nameplates, submit a complete schedule to Architect for approval indicating nameplate size, lettering size, color and actual nameplate information.

C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.6 QUALITY ASSURANCE

A. Comply with ANSI A13.1 and ANSI C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.145.

1.7 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Manufacturers: Brady USA, Ideal, Marking Services, Inc. (MSI), Seton, or approved equal.

C. Color for Printed Legend:
   1. Power Circuits: Black letters on an orange field.
   2. Legend: Indicate system or service and voltage, if applicable.

D. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

E. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action when placed in position.

F. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2” long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action when placed in position.

G. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2” wide; compounded for outdoor use.

2.2 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend.

B. Manufacturers: Brady USA, Ideal, Marking Services, Inc. (MRI), Seton, or approved equal.

C. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2” wide.

D. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

E. Aluminum Wraparound Marker Labels: Cut from 0.014” thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.

F. Metal Tags: Brass or aluminum, 2” x 2” x 0.05”, with stamped legend, punched for use with self-locking nylon tie fastener.

G. Write-On Tags: Polyester tag, 0.010” thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
   1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

H. Plasticized Card-Stock Tags: Vinyl cloth with preprinted and field-printed legends. Orange background, unless otherwise indicated, with eyelet for fastener.

2.3 UNDERGROUND-LINE WARNING TAPE

A. Manufacturers: Brady USA, Ideal, Marking Services, Inc. (MRI), Seton, or approved equal.

B. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
   1. Not less than 6” wide by 4 mils thick.
   2. Compounded for permanent direct-burial service.
   3. Embedded continuous metallic strip or core.
   4. Printed legend shall indicate type of underground line.

2.4 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Self-Adhesive Arc Flash Warning Labels: Industrial grade, made of durable polyester with over-laminate to withstand harsh environments (UV rays, scratches and most chemicals).
   1. Manufacturer: Seton or approved equal

D. Engraved Plastic Signs: Engraving stock, melamine plastic laminate, minimum 1/16” thick for signs up to 20 sq in and 1/8” thick for larger sizes.
   1. Engraved legend with black letters on white face.
   2. Punched or drilled for mechanical fasteners.

E. Baked-Enamel Warning Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4" grommets in corners for mounting. Nominal size, 7” x 10”.

F. Metal-Backed, Butyrate Warning Signs for Exterior Use: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396” galvanized-steel backing; and with colors, legend, and size required for application. 1/4" grommets in corners for mounting. Nominal size, 10” x 14”.

G. Warning label and sign shall include, but are not limited to, the following legends:
   1. Multiple Power Source Warning: “DANGER – ELECTRICAL SHOCK HAZARD – EQUIPMENT HAS MULTIPLE POWER SOURCES.”
   2. Workspace Clearance Warning: “WARNING – OSHA REGULATION – AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES.”
   3. Arc Flash Labels: Per ANSI Z535.4, the signal word WARNING appearing in black letters on an orange background, with second line below (Arc Flash and Shock Hazard) in black letters on white background and third line below (Appropriate PPE Required) in black letters on white background. Include the following information on the label:
      a. Equipment name
      b. Available bolted current
      c. Flash protection boundary distance
      d. Incident energy level at 18” expressed in cal/cm^2
      e. Personnel protective equipment (PPE) class
      f. Voltage shock hazard
      g. Limited shock approach boundary
      h. Restricted shock approach boundary
      i. Prohibited shock approach boundary

2.5 INSTRUCTION SIGNS AND POSTED DRAWINGS

A. Instruction Signs: Engraved, laminated acrylic or melamine plastic, minimum 1/16” thick for signs up to 20 sq in and 1/8” thick for larger sizes.
   1. Engraved legend with black letters on white face
   2. Punched or drilled for mechanical fasteners.
   3. Mounting Frames: Extruded aluminum, 4-point screw mount with 1/8” clear plexiglass cover.

B. Posted Drawings: Print electrical riser diagrams on 20 lb bond paper. (Blueprint paper is not acceptable.) Reduce drawings to approximately 1/2 size using Xerox reduction process. Contact Engineer to obtain updated original plans for printing.

2.6 EQUIPMENT IDENTIFICATION NAMEPLATES

A. Engraved, Three-layer, Laminated Acrylic or Melamine Nameplate: Punched or drilled for screw mounting. White letters on a black background, except emergency power equipment nameplates are to have white letters on a red background. Minimum letter height shall be 3/8” unless noted otherwise.

B. Stenciled Legend: In non-fading, waterproof, black ink or oil-based, alkyd enamel paint. Minimum letter height shall be 1”.

2.7 WIRING DEVICES IDENTIFICATION

A. Refer to Section 26 2726 – Wiring Devices for requirements.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, type 6/6 nylon cable ties.
   1. Minimum Width: 3/16”
   2. Tensile Strength: 50 lb minimum
   3. Temperature Range: -40 to +185°F
   4. Color: Black, except where used for color-coding

B. Paint: Paint materials and application requirements are specified in Division 09 – Finishes painting Sections.

C. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 APPLICATION

A. Raceway and Ductbanks More Than 600 V Concealed within Buildings: 4” wide black stripes on 10” centers over orange background that extends full length of raceway or duct and is 12” wide. Stencil legend “DANGER CONCEALED HIGH-VOLTAGE WIRING” with 3” high black letters on 20” centers. Stop stripes at legends. Apply to the following finished surfaces:
   1. Floor surface directly above conduits running beneath and within 12” of a floor that is in contact with earth or is framed above unexcavated space.
   2. Wall surfaces directly external to raceways concealed within wall.
   3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.

B. Accessible Raceways 600 V or Less, for Service, Feeder, and Branch Circuits More Than 100A: Identify with orange self-adhesive vinyl labels.
   1. Identify 4" round, 4" square and 4-11/16" junction boxes concealed above ceiling or exposed with neat lettering on cover with permanent black marking pen. Identify source, circuit number, phase, and control circuit number.

C. Accessible Raceways and Cables of Auxiliary Electrical Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands:
   1. Fire Alarm System (including covers of pull and junction boxes): Red
   2. Fire-Suppression Supervisory and Control System: Red and yellow
   3. Security System: Blue and yellow
   4. Mechanical and Electrical Supervisory System: Green and blue
   5. Telecommunication System: Green and yellow

D. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use color-coding conductor tape. Identify source and circuit number of each set of conductors or other appropriate number or letter to expedite future tracing and troubleshooting. For single conductor cables, identify phase in addition to the above. Phase identification shall be consistent throughout the system.

E. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.

F. Conductors to Be Extended in the Future and Spare Conductors: Attach write-on tags to conductors and list source and circuit number.

G. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
   3. Coordinate identification with project drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

H. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Limit use of underground-line warning tape to direct-buried cables.

I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access to equipment.
   1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:
      a. Power transfer switches
      b. Controls with external control power connections
   2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

3. Arc Flash Warning Labels: install per NFPA 70 for each switchgear, switchboard, panelboard, motor control center, industrial control panel (every enclosure that may contain energized conductors or components). Locate labels so they are visible to the personnel before examination, adjustment, servicing, or maintenance of the equipment.

J. Instruction Signs and Posted Drawings:

1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend printed in all capital letters of 12 pt size minimum where instructions are needed for system or equipment operation.

K. Equipment Identification Nameplates: On each unit of equipment, install unique designation nameplate that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply nameplates to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Nameplate Instructions:
   a. Indoor Equipment: Engraved, laminated acrylic or melamine nameplate. Unless otherwise indicated, provide a single line of text with 1/2" high letters (1/4” where space is limited) on 1-1/2” high nameplate; where 2 lines of text are required, use nameplates sized 2” high.
   b. Outdoor Equipment: Engraved, laminated acrylic or melamine nameplates sized similar to indoor equipment nameplates.
   c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
2. Install nameplates for equipment including, but not limited to, the following:
   a. Panelboards, electrical cabinets, and enclosures
   b. Access doors and panels for concealed electrical items
   c. Electrical switchgear and switchboards, including each device
   d. Transformers
   e. Electrical substations
   f. Emergency system boxes and enclosures
   g. Motor-control centers, including each device
   h. Disconnect switches
   i. Enclosed circuit breakers
   j. Motor controllers
   k. Pushbutton stations
   l. Power transfer equipment
   m. Contactors
   n. Remote-controlled switches, dimmer modules, and control devices
   o. Battery inverter units
   p. Battery racks
   q. Power-generating units
   r. Voice and data cable terminal equipment
   s. Master clock and program equipment
   t. Intercommunication and call system master and staff stations
   u. Television/audio components, racks, and controls
   v. Fire alarm control panel and annunciators

w. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks

x. Monitoring and control equipment

y. Uninterruptible power supply equipment

z. Terminals, racks, and patch panels for voice and data communication and for signal and control functions

aa. Non-concealed junction box covers of auxiliary electrical systems

3. Nameplates shall identify equipment or load controlled and/or function and shall be same as indicated on contract documents. Voltages shall be shown on panelboard nameplates.

L. Access Panel Identification: Furnish typewritten charts with identification and location of access panels serving equipment and incorporate in O&M Manuals.

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Install non-adhesive signs and plastic nameplates parallel to equipment lines; attach with screws and auxiliary hardware appropriate to the location and substrate. Secure to inside surface of door or panelboard that is recessed in finished locations.

F. Posted Drawings and Operating Instructions: Mount drawings and operating procedures on the wall immediately adjacent to the piece of equipment for which the instructions apply. If sufficient wall space is available, mount directly to one of the sheet metal panels of the equipment.

G. Warning Signs: Install warning signs where there is hazardous exposure or danger associated with access to or operation of electrical facilities. Provide text of sufficient clarity and lettering of sufficient size to convey adequate information at each location; mount permanently in an appropriate and effective location. Comply with ANSI A13.1 standard color and design.

1. Operational Tags: Where needed for proper and adequate information on operation and maintenance of electrical systems, provide tags of plasticized card stock, either preprinted or hand printed to convey the message; example: “DO NOT OPEN THIS SWITCH WHEN BREAKER IS CLOSED.”

H. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.

I. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, branch-circuit, service, feeder, and branch-circuit conductors.

1. Color shall be factory applied, or, for sizes larger than No. 10 AWG if authorities having jurisdiction permit, field applied.

2. Colors for 208/120 V Circuits:

a. Phase A (left bus in panelboard): Red

b. Phase B (center bus in panelboard): Black

c. Phase C (right bus in panelboard): Blue

d. Neutral: White
e. Equipment Ground: Green

3. Colors for 480/277 V Circuits:
   a. Phase A (left bus in panelboard): Orange
   b. Phase B (center bus in panelboard): Yellow
   c. Phase C (right bus in panelboard): Brown
   d. Neutral: Gray
   e. Equipment Ground: Green
4. Field-applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6” from terminal points and in boxes where splices or taps are made. Apply last two runs of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

J. Aluminum Wraparound Marker Nameplates and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

K. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8” below finished grade. Use multiple tapes where width of multiple lines installed in a common trench [or concrete envelope] exceeds 16” overall.

L. Painted Identification: Prepare surface and apply paint according to Division 09 – Finishes painting Sections.

End of Section

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SECTION 26 05 73

OVERCURRENT PROTECTIVE DEVICE COORDINATION AND ARC FLASH STUDY

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 08 12 – Power Distribution Acceptance Tests

B. Section 26 08 13 – Power Distribution Acceptance Test Tables

C. Section 26 12 16 – Dry-Type, Medium-Voltage Transformers

D. Section 26 22 00 – Low-Voltage Transformers

E. Section 26 23 00 – Low-Voltage Switchgear

F. Section 26 24 16.13 – Lighting and Appliance Panelboards

G. Section 26 24 16.16 – Distribution Panelboards

H. Section 26 28 13 – Fuses

I. Section 26 28 16 – Enclosed Switches and Circuit Breakers

J. Section 26 29 13 – Enclosed Controllers

K. Section 26 36 23 – Automatic Transfer Switches

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 DESCRIPTION

A. Section includes computer based, fault current, arc flash, and overcurrent protective device coordination studies for an electrical distribution system, based on actual equipment supplied. Set protective devices based on results of the protective device coordination study.

1. Series-rated devices are not permitted.

B. Furnish field information and data needed for the studies.

C. Available fault current and electrical equipment interrupting capacity indicated on drawings are based on the short circuit study performed during design as part of the construction documents.

D. Provide studies and reports prior to manufacture of the electrical distribution equipment.

E. Equipment submittal will not be approved until the coordination study is complete and the equipment submittals indicate compliance with the study recommendations.

F. Arc flash labels shall be installed prior to energizing equipment.

1.4 REFERENCE STANDARDS

A. ANSI C57.12.22 – American National Standard for Transformers-Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings, 2500 kVA & Smaller: High-Voltage, 34 500 GrdY/19 920 V & Below; Low Voltage, 480 V & Below-Requirements

B. ANSI C57.96 – Distribution and Power Transformers, Guide for Loading Dry-Type (Appendix to ANSI C57.12 Standards)

C. IEEE 241 – Recommended Practice for Electric Power Systems in Commercial Buildings

D. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

E. IEEE 399 – Recommended Practice for Power System Analysis

F. IEEE 620 – Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines

G. IEEE 1015 – Recommended Practice for Applying Low-Voltage Circuit Breakers Used in Industrial and Commercial Power Systems

H. IEEE 1584 – Guide for Performing Arc-Flash Hazard Calculations

I. IEEE C37.010 – Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

J. IEEE C37.20.1 – IEEE Standard for Metal-Enclosed, Low-Voltage Power Circuit Breaker Switchgear

K. IEEE 37.46 – American National Standard Specifications for Power Fuses and Fuse-Disconnecting Switches

L. IEEE C57.96 – IEEE Guide for Loading Dry-Type Distribution and Power Transformers

M. ICEA P-32-382 – Short-Circuit Characteristics of Insulated Cable

N. ICEA P-45-482 – Short-Circuit Performance of Metallic Shielding and Sheaths of Insulated Cable

O. NEMA MG 1 – Motors and Generators

P. NFPA 70 – National Electrical Code (NEC)

Q. NFPA 70E – Standard for Electrical Safety in Workplace

1.5 SUBMITTALS

A. Product Data: Computer software program to be used for studies.

B. Product Certificates:
   1. Coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.
   2. Arc flash calculations computer software programs, certifying compliance with IEEE 1584.

C. Qualification Data: For coordination study specialist.

1. Submit qualifications of the organization proposed for performing the study. Include description of the equipment and computer-based computation methods or programs used and the names and experience histories of the personnel who will perform the study.

D. Other Action Submittals: Subsequent to having approval for system protective devices submit the following::
1. Fault current study report
2. Equipment evaluation report
3. Coordination study input data, including completed computer program input data sheets
4. Coordination Study Report
5. Arc Flash Study and Report
6. Arc Flash labels
7. All software files to allow review and future use of files

1.6 QUALITY ASSURANCE

A. Perform studies using computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Coordination Study Specialist Qualifications: An organization experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
1. Perform study under the direct supervision and control of a Registered Professional Electrical Engineer licensed in the State of Illinois, with a minimum of 5 yrs recent experience in performing protective device coordination studies, arc flash calculations, and electrical system analysis.

C. Comply with IEEE 242 for short circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

E. Comply with IEEE 1584 for arc flash calculations.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:

B. Basis of Design Product:
1. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399 and IEEE 1584.

B. Analytical features of fault current study computer software program shall include “mandatory,” “very desirable,” and “desirable” features as listed in IEEE 399 Table 7-4.

C. Computer software program shall be capable of plotting and diagramming time-current characteristic curves as part of its output. Computer software program reports device settings and ratings of all overcurrent protective devices and demonstrates selective coordination by computer-generated, time-current coordination plots.

D. Arc Flash Calculations: Software program capable of calculating Arc Flash Incident Energy (AFIE) levels and flash protection boundary distances.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices for coordination are indicated on drawings.

B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

C. Provide the study based on the actual electrical equipment supplied for the project.

3.2 POWER SYSTEM DATA

A. Gather and tabulate the following input data to support coordination study:
   1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with power riser diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
   2. Impedance of utility service entrance.
   3. Power Riser Diagrams: In hard copy and electronic copy formats, showing the following:
      a. Circuit breaker and fuse-current ratings and types
      b. Relays and associated power and current transformer ratings and ratios
      c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios
      d. Generator kilovolt amperes, size, voltage, and source impedance
      e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length
      f. Busway ampacity and impedance
      g. Motor horsepower and code letter designation according to NEMA MG 1
      h. Load current that is the basis for sizing continuous ratings of circuits for cables and equipment
   4. Data sheets to supplement power riser diagrams, cross-referenced with tag numbers on diagrams, showing the following:
      a. Special load considerations, including starting inrush currents and frequent starting and stopping
      b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability
      c. Motor full-load current, locked-rotor current, service factor, starting time, type of start, and thermal-damage curve
      d. Generator thermal-damage curve
      e. Ratings, types, and settings of utility company's overcurrent protective devices
      f. Special overcurrent protective device settings or types stipulated by utility company
      g. Time-current characteristic curves of devices indicated to be coordinated
      h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers

i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays

j. Panelboards, distribution panelboards and switchgear ampacity, and interrupting rating in amperes rms symmetrical

3.3 FAULT CURRENT STUDY

A. Calculate maximum available short circuit current in amperes rms symmetrical at circuit breaker positions of electrical power distribution system. Provide calculation for a current immediately after initiation and for a three-phase bolted short circuit at the following:

1. Switchgear and switchboard bus
2. Distribution panelboard
3. Branch circuit panelboard
4. Disconnect switches
5. Automatic Transfer Switch
6. Uninterruptible Power Supply

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for project. Include studies of system switching configurations and alternate operations that could result in maximum fault conditions.

1. Model the entire electrical distribution system from Laboratory 13200 volt transformer point of connection to circuit breakers in branch circuit panels at secondary side of distribution transformers. Include mechanical HVAC equipment, motor driven equipment feeder circuits, and elevator feeder circuits.
2. Model shall include components of the distribution system which would be exposed to fault current levels of 10,000 A symmetrical on a calculated basis.

C. Calculate momentary and interrupting duties on basis of maximum available fault current.

D. Perform calculations to verify interrupting ratings of overcurrent protective devices in compliance with IEEE 241 and IEEE 242.

1. Transformers:
   a. ANSI C57.12.10
   b. ANSI C57.12.22
   c. ANSI C57.12.40
   d. IEEE C57.12.00
   e. IEEE C57.96
2. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1
3. Low-Voltage Fuses: IEEE C37.46

E. Study Report:

1. Show calculated X/R ratios and equipment interrupting rating (5-cycle) fault currents on power riser diagrams in report. List other output values from computer analyses, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault current values for 3-phase, 2-phase, and phase-to-ground faults.
2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium- voltage circuit breakers/switches to set relays and assess the sensitivity of overcurrent relays.

F. Equipment Evaluation Report:

1. Prepare report on adequacy of overcurrent protective devices and conductors by comparing fault current ratings of devices with calculated fault current momentary and interrupting duties.

2. For 600V overcurrent protective devices, ensure interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
3. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
4. Verify adequacy of phase conductors at maximum 3-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure short circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
5. Notify ANL/Engineer promptly of discrepancies, problem areas, or inadequacies and provide recommendations for problem resolution.

3.4 COORDINATION STUDY

A. Perform coordination study using approved computer software program. Prepare a written report using results of fault current study. Comply with IEEE 399.
   1. Calculate maximum and minimum 1/2-cycle short circuit currents.
   2. Calculate maximum and minimum interrupting duty (5 cycles to 2 seconds) short circuit currents.
   3. Calculate maximum and minimum ground-fault currents.

B. Comply with NFPA 70 for overcurrent protection of circuit elements and devices.

C. Comply with IEEE 241recommendations for fault currents and time intervals.

D. Transformer Primary Overcurrent Protective Devices:
   1. Devices non-operational in response to the following:
      a. Inrush current when first energized
      b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
      c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
   2. Protect transformers according to IEEE C57.12.00, for fault currents by device settings.

E. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate equipment withstands the maximum short circuit current for a time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short circuit current. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.

F. Include voltage classes of equipment from utility's incoming line protective device down to and including each panelboard. The phase and ground overcurrent protection shall be included as well as settings for other adjustable protective devices.

G. Coordination Study Report: Prepare a written report indicating results of coordination study:
   1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
      a. Device tag
      b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values
      c. Circuit breaker sensor rating; and long-time, short-time, and instantaneous settings
      d. Fuse-current rating and type
      e. Ground-fault relay-pickup and time-delay settings

f. Manufacturer and type of device

g. Range of adjustments and recommended settings

2. Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate adequate time separation exists between devices installed in series, drawn to show the boundaries of device operation on log-log scale graphs, including power utility company's upstream devices. Include on curve sheet a title and legend identifying portion of the system covered. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

   a. Device tag

   b. Voltage and current ratio for curves

   c. Three-phase and single-phase damage points for each transformer

   d. No damage, melting, and clearing curves for fuses

   e. Cable damage curves

   f. Transformer inrush points

   g. Maximum fault current cutoff point

3. Plot characteristics where applicable:

   a. Medium-and low- voltage fuses including minimum melt, total clearing and damage bands

   b. Low-voltage circuit breaker trip devices

   c. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters

   d. Ground-fault protective devices

   e. Motor starting characteristics and motor damage points

   f. Generator short circuit decrement curve and generator damage point

   g. Conductor damage curves

   h. Electric utility's protective devices

   i. Medium-voltage equipment relays

4. Notify ANL/Engineer promptly of discrepancies, problem areas, or inadequacies and provide recommendations for problem resolution. Propose approaches to effectively protect the underrated equipment. Present technical evaluation with discussion of logical compromises for best coordination.

H. Completed data sheets for setting of overcurrent protective devices.

3.5 ARC FLASH STUDY

A. Perform arc flash calculations for Arc Flash Incident Energy (AFIE) levels and flash protection boundary distances. Utilize short circuit rating of equipment identified in fault current study.

B. Model worst-case arc flash conditions.

1. Equipment with PPE rating greater than 2 shall be investigated. Investigation shall include adjustment of upstream overcurrent device settings to determine if PPE rating can be reduced with minimal compromise to coordination with other overcurrent devices.

2. Study shall include "Maintenance Settings" with resulting PPE rating. Adjustable breakers shall be set to lowest instantaneous setting available.

C. Arc Flash Study Report: Provide study results in tabular form and include:

1. Device or bus name

2. Bolted fault and arcing fault current levels

3. Arc Flash Incident Energy (AFIE) level at 18" expressed in cal/cm^2

4. Flash protection boundary distances including:
   a. Limited shock approach boundary
   b. Restricted shock approach boundary
   c. Prohibited shock approach boundary
5. Personal protective equipment class (PPE)

D. Provide recommendation for reducing AFIE levels and enhancing worker safety.

3.6 FIELD QUALITY CONTROL

A. Inspect, set, test, and calibrate the protective relays, circuit breakers, fuses, and other applicable devices per requirements in Section 26 0812 – Power Distribution Acceptance Tests and Section 26 0813 – Power Distribution Acceptance Test Tables.

B. Upon final approval of study, provide weatherproof vinyl or polyester arc flash label for all electrical equipment defined above. Label shall include calculated flash protection boundary, incident energy at working distance of 18”, required PPE level, limited approach, restricted approach, and prohibited approach boundaries, equipment name, overcurrent device settings if applicable, and date label was produced.
   1. PPE label shall be color coded as follows:
      a. Category 0 or 1 – Green
      b. Category 2 – Yellow
      c. Category 3 – Orange
      d. Category 4 – Red

3.7 ADJUSTING

A. Make modifications to equipment, as required, to accomplish conformance with equipment evaluation study.

B. Adjust relay and overcurrent protective device settings according to recommended settings table provided by overcurrent protective device coordination study.

C. Notify ANL/Engineer in writing of any required major modifications.

3.8 INSTALLATION

A. Install PPE labels on each piece of equipment prior to energizing equipment.

B. PPE labels shall be protected by clear plastic cover, weatherproof type material, or laminated and mounted on front of equipment. Taping of PPE label to front of equipment is unacceptable.

C. PPE label shall be clearly visible upon approach to equipment.

D. For large pieces of equipment, label shall be placed near main overcurrent device or incoming feeder to equipment.

E. Label shall be mounted at a minimum of 42” to bottom and maximum 66” to top above finished floor.

End of Section

SECTION 26 05 93

ELECTRICAL SYSTEMS FIRESTOPPING

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 07 84 13 – Penetration Firestopping

B. Section 26 05 33 – Raceways and Boxes for Electrical Systems

C. Section 26 05 36 – Cable Trays for Electrical Systems

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes through-penetration firestop systems for penetrations through fire-resistance-rated constructions (walls, partitions, floors, and ceilings) including both empty openings and openings containing electrical penetrating items, including but not limited to raceways, cables, cable trays, busways, and wireways.

1.4 REFERENCE STANDARDS

A. ASTM E-814 - Standard Test Method for Fire Tests of Through-Penetration Firestops

B. UL 1479 - Fire Tests of Through-Penetration Firestops

C. UL 2079 - Tests For Fire Resistance of Building Joint Systems

1.5 PERFORMANCE REQUIREMENTS

A. Provide firestop system to resist spread of fire, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

B. Firestop systems shall be UL Classified for the application and correspond to those indicated by reference to designations listed by UL Fire Resistance Directory.

C. Conform to applicable Code requirements of Authority Having Jurisdiction.

D. For through-penetration firestop systems exposed to view, traffic, moisture, and physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions.

1.6 SUBMITTALS

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

B. Shop Drawings: For each through-penetration firestop system, show each type of construction condition penetrated, relationships to adjoining construction, and type of penetrating item. Include firestop design designation of qualified testing and inspecting agency that evidences compliance with requirements for each condition indicated.

1. Submit documentation, including illustrations, from a qualified testing and inspecting agency that is applicable to each through-penetration firestop system configuration for construction and penetration items, including documentation of UL certification for firestop systems.

C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

D. Material Safety Data Sheets provided with product delivered to job site.

E. Certification of compliance with Building Codes of the State of Project location.

F. Inspection reports

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A firm experienced in installing through-penetration firestop systems similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful performance.

B. Firestopping tests shall be performed by a qualified testing and inspecting agency, or another agency performing testing and follow-up inspection services for firestop systems acceptable to Authorities Having Jurisdiction.

C. Manufacturer's representative shall be on-site during initial installation of firestop systems to train appropriate Contractor personnel in proper selection and installation procedures.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver through-penetration firestop system products to Project site in original, unopened containers or packages with intact and legible manufacturers' labels identifying product, type and manufacturer, and UL Label where applicable.

B. Store and handle materials for through-penetration firestop systems to prevent their deterioration or damage due to moisture, temperature changes, contaminants, or other causes.

C. Handle in accordance with recommended procedures, precautions, or remedies described in material safety data sheets as applicable.

1.9 PROJECT CONDITIONS

A. Do not install through-penetration firestop systems when ambient or substrate temperatures are outside limits permitted by through-penetration firestop systems' manufacturers or when substrates are wet due to rain, frost, condensation, or other causes.

B. Ventilate through-penetration firestop systems per manufacturers' written instructions by natural means or, where this is inadequate, forced-air circulation.

1.10 COORDINATION

A. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.

B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.

C. Notify ANL's inspecting agency at least 7 days in advance of through-penetration firestop system installations; confirm dates and times on days preceding each series of installations.

D. Do not cover up through-penetration firestop system installations that will become concealed behind other construction until each installation has been examined by ANL's inspecting agency and building inspector, if required by Authorities Having Jurisdiction.

1.11 SEQUENCING

A. Sequence work to avoid interferences with building finishes and installation of other products.

1.12 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. 3M (Fire Protection Products Division), Hilti Inc, Tremco (Sealant/Weatherproofing Division), Nelson Firestop Products, Specified Technologies Inc, RectorSeal Corporation, or approved equal.

2.2 MATERIALS

A. Firestop Products: UL 1479, ASTM E-814 tested for specific fire-rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements and fire-rating involved for each separate instance; materials shall not contain flammable solvents.

B. Firestop Systems: Produced by the same manufacturer.

C. Accessories: Components for each through-penetration firestop system that are needed to install fill materials and to comply with Part 1 "Performance Requirements" Article. Accessories include the following items:
   1. Permanent forming/damming/backing materials
   2. Temporary forming materials
   3. Substrate primers
   4. Collars
   5. Steel sleeves

D. Fill Materials: Including the following:
   1. Firestop putty, caulk sealant, intumescent wrap strips, intumescent firestop collars, firestop mortars, pillows/bags, or a combination of these products to provide a UL-listed system for each application required for this Project; mineral wool backing where specified in manufacturer's application detail.

E. Mixing
   1. For those products requiring mixing before application, comply with through-penetration firestop system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for opening configurations, penetrating items and other conditions affecting performance of firestopping.

B. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean out openings immediately prior to installing through-penetration firestop system to comply with firestop system manufacturer's written instructions.

B. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.

C. Comply with manufacturer's recommendations for temperature and humidity conditions before, during and after installation of firestopping.

3.3 INSTALLATION

A. Comply with "System Performance Requirements" Article in Part 1 and with firestop system manufacturer's written installation instructions and drawings for products and applications indicated.

B. Install forming/damming/backing materials and other accessories of types required to support fill materials during application as required. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.

C. Avoid multiple penetrations of common fire barrier opening. Seal each penetration in accordance with manufacturer's UL installation details. When multiple penetrations are unavoidable, seal openings with appropriate UL Classified firestopping systems.

3.4 IDENTIFICATION

A. Identify through-penetration firestop systems with pressure-sensitive, self-adhesive, preprinted vinyl labels. Attach labels permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be visible to anyone seeking to remove penetrating items or firestop systems. Include the following information on labels:

1. The words: "Warning—Through-Penetration Firestop System—Do Not Disturb. Notify Building Management of Any Damage."
2. Contractor's name, address, and phone number
3. Through-penetration firestop system designation of applicable testing and inspecting agency
4. Date of installation
5. Through-penetration firestop system manufacturer's name
6. Installer's name

3.5 FIELD QUALITY CONTROL

A. Inspecting Agency: ANL will engage a qualified independent inspecting agency to inspect through-penetration firestop systems and to prepare test reports.

1. Inspecting agency will state in each report whether inspected through-penetration firestop systems comply with or deviate from requirements.

B. Provide certification by Installer that all through-penetration firestop systems have been firestopped in accordance with applicable Building Codes of the State of Project location.

C. Proceed with enclosing through-penetration firestop systems with other construction only after inspection reports are issued and firestop installations comply with requirements.

D. Where deficiencies are found, repair or replace through-penetration firestop systems so they comply with specifications.

3.6 CLEANING

A. Clean surfaces adjacent to sealed holes and joints to be free of excess firestop materials and soiling as work progresses.

End of Section

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SECTION 26 08 12

POWER DISTRIBUTION ACCEPTANCE TESTS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 0513.16 – Medium-Voltage, Single- and Multi-Conductor Cables

B. Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables

C. Section 26 0526 – Grounding and Bonding for Electrical Systems

D. Section 26 0573 – Overcurrent Protection Device Coordination Study

E. Section 26 0813 – Power Distribution Acceptance Test Tables

F. Section 26 1216 – Pad-Mounted, Cast Coil, Medium-Voltage Transformers

G. Section 26 2200 – Low-Voltage Transformers

H. Section 26 2300 – Low-Voltage Switchgear

I. Section 26 2816 – Enclosed Switches and Circuit Breakers

J. Section 26 3623 – Automatic Transfer Switches

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 DESCRIPTION

A. Section includes acceptance testing requirements for assessing the suitability for service and reliability of the power distribution system.

B. It is the purpose of this specification to assure all tested electrical equipment, both contractor and ANL supplied, is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.

C. Tests and inspections shall be performed after installation.

D. Tests and inspections shall determine suitability for energization.

E. Electrical systems shall pass tests prior to substantial completion or ANL occupancy.

F. This specification requires contractor to engage services of testing agency.

G. All tests tables referenced in this specification provided in Section 26 0813 – Power Distribution Acceptance Test Tables.

H. Items to be tested and inspected as follows:
   1. 600-volt conductors and cables
   2. Medium-voltage cables
   3. Dry type transformers (small)
   4. Dry type transformers (large)
   5. Liquid filled transformers
   6. Low-voltage switchgear
   7. Low-voltage power circuit breakers
   8. Low-voltage insulated-case/molded-case circuit breakers
   9. Low-voltage disconnect switches
   10. Medium-voltage surge arresters
   11. Network protectors (600 V class)
   12. Automatic transfer switches
   13. Motor control and motor control center
   14. Ground fault protection systems
   15. Grounding systems
   16. Protective relays (as applicable)
   17. Instrument transformers
   18. Thermographic survey

I. ANSI/IEEE C2 – National Electrical Safety Code

J. ANSI/IEEE C37 – Guides and Standards for Circuit Breakers, Switchgear, Relays, Substations, and Fuses

K. ANSI/IEEE C37.04 – Standard Rating Structure for AC High Voltage Circuit Breaker

L. ANSI/IEEE C57 – Distribution, Power, and Regulating Transformers

M. ANSI/IEEE C57.13.1 – Guide for Field Testing of Relaying Current Transformers

N. ANSI/IEEE C57.13.3 – Grounding of Instrument Transformer Secondary Circuits and Gases

O. ANSI/IEEE C57.104 – Guide for the Interpretation of Gases Generated in Oil-immersed Transformers

P. ANSI/IEEE C62 – Surge Protection

Q. ANSI/IEEE Std. 43 – IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machinery

R. ANSI/IEEE Std. 48 – Standard Test Procedure and Requirements for High-Voltage Alternating-Current Cable Terminations

S. ANSI/IEEE Std. 81 – Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

T. ANSI/IEEE Std. 141 – IEEE Recommended Practice for Electrical/Power Distribution for Industrial Plants (IEEE Red Book)

U. ANSI/IEEE Std. 142 – IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (IEEE Green Book)

V. ANSI/IEEE Std. 241 – IEEE Recommended Practice for Electrical Power Systems in Commercial Buildings (IEEE Gray Book)

W. ANSI/IEEE Std. 242 – IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)

X. ANSI/IEEE Std. 399 – IEEE Recommended Practice for Power Systems Analysis (IEEE Brown Book)

Y. ANSI/IEEE Std. 400 – Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field

Z. ANSI/IEEE Std. 446 – IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications (IEEE Orange Book)

AA. ANSI/IEEE Std. 493 – IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (IEEE Gold Book)

BB. ANSI/IEEE Std. 1100 – IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (IEEE Emerald Book)

CC. ASTM D877 – Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

DD. ASTM D823 – Standard Practices for Sampling Electrical Insulating Liquids

EE. ASTM D924 – Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids

FF. ASTM D971 – Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Methods

GG. ASTM D974 – Standard Test Method for Acid and Base Number by Color-Indicator Titration

HH. ASTM D1298 – Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

II. ASTM 1500 – Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)

JJ. ASTM D1524 – Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field

KK. ASTM D1816 – Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes

LL. ASTM D2285 – Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop-Weight Method

MM. ASTM D3612 – Standard Test Method for Analysis of Gases Dissolved in Electrical Insulating Oil by Gas Chromatography

NN. ASTM D3613 – Standard Practice for Sampling Insulating Liquids for Gas Analysis and Determination of Water Content

OO. NETA – Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems

PP. NEMA AB 4 – Guidelines for Inspection and Preventive Maintenance of Molded-Case Circuit Breakers Used in Commercial and Industrial Applications

QQ. NEMA MG1 – Motors and Generators

RR. NFPA 70 – National Electrical Code

SS. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance

TT. NFPA 70E – Electrical Safety Requirements for Employee Workplaces

UU. NFPA 101 – Life Safety Code

VV. NFPA 110 – Emergency and Standby Power Systems

WW. NIST – National Institute of Standards and Technology

XX. OSHA – Part 1910 – Subpart S – 1910.308 – Special Systems

1.4 SUBMITTALS

A. Test Reports: Include the following:
1. Summary of project
2. Description of equipment tested
3. Equipment used to conduct the test
4. Description of test
5. Test results, as compared to manufacturers' or industry accepted standards and tolerances
6. Conclusions and recommendations
7. Signature of responsible test organization authority

B. List of equipment used to perform tests. Identify the following:
1. Type
2. Manufacturer
3. Model number
4. Serial number
5. Date of last calibration
6. Documentation of calibration leading to NIST standards

1.5 QUALITY ASSURANCE

A. Qualifications of Testing Agency:
1. Testing firm shall be a corporately and financially independent testing organization that can function as an unbiased testing authority, professionally independent of the manufacturer, supplier, and installers of equipment or system evaluated by the testing firm.
2. Testing firm shall be regularly engaged in testing of electrical equipment, devices, installations and systems.
3. Testing firm shall meet Federal Occupational Safety and Health Administration (OSHA) requirements for accreditation of independent testing laboratories.
4. On-site technical person shall be currently certified by the International Electrical Testing Association in electrical power distribution system testing.
5. Testing firm shall use technicians who are regularly employed by the firm for testing services.

6. Testing firm shall submit proof of above qualifications with bid documents when requested.

PART 2 - PRODUCTS

2.1 Not applicable to this Section.

PART 3 - EXECUTION

3.1 PREPARATION

A. Documentation: Deliver the following to testing firm, minimum two weeks prior to commencement of testing:
   1. Complete set of electrical plans and specifications, with available short circuit indicated on power riser diagrams.
   2. Approved submittals and shop drawings of equipment being tested.
   3. Pertinent change orders.
   4. Evaluation, overcurrent protective device coordination and arc flash studies, per requirements in Section 26 0573 – Overcurrent Protection Device Coordination Study.

B. Schedule: Notify ANL and Engineer 10 working days prior to performance of any tests.

C. Coordination: Coordinate with Construction Manager/ANL/Engineer the testing schedule and availability of equipment ready for testing.

D. Test Power: Provide test power (including specialized) for equipment testing before and after service energizing.

3.2 FIELD QUALITY CONTROL

A. Inspection and Test Procedures: Comply with NETA.
   1. 600 V Conductors and Cables:
      a. Visual and Mechanical Inspection:
         1) Compare cable data with drawing and specifications.
         2) Inspect exposed sections of cables for physical damage.
         3) Verify tightness of accessible bolted electrical connections by calibrated torque wrench in accordance with manufacturer's published data or Table 12.
         4) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."
         5) Inspect compression-applied connectors for correct cable match and indentation.
         6) Verify visible cable bends meet or exceed ICEA and manufacturer's minimum allowable bending radius.
         7) For cables are terminated through window-type current transformers, provide an inspection to verify neutral and ground conductors are correctly placed for operation of protective devices.
         8) Inspect for correct identification and arrangements.
         9) Inspect jacket and insulation condition.
      b. Electrical Tests:
         1) Perform insulation-resistance test using megohm meter. Applied potential to be 1000 VDC. Individually test each conductor with other conductors grounded. Test duration shall be one minute.
         2) Perform continuity tests to insure correct cable connection.

c. Test Values:

1) Insulation-resistance values should not be less than 50 megohms.

2. Medium-Voltage Cables:

a. Visual and Mechanical Inspection:

1) Compare cable date with drawings and specifications.

2) Inspect exposed sections of cables for physical damage.

3) Verify tightness of accessible bolted connections by calibrated torque wrench in accordance with manufacturer's published data or Table 12.

4) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."

5) Inspect compression-applied connectors for correct cable match and indentation.

6) Inspection for shield grounding, cable support, and termination.

7) Verify visible cable bends meet or exceed ICEA and manufacturer's minimum allowable bending radius.

8) Inspect for adequate fireproofing in common cable areas, if specified.

9) For cables are terminated through window-type current transformers, provide an inspection to verify neutral and ground conductors are correctly placed and shields are correctly terminated for operation of protective devices.

10) Inspect jacket and insulation condition.

11) Inspect for correct identification and arrangements.

b. Electrical Tests:

1) Perform shield-continuity test on each power cable by ohmmeter method and record value.

2) Perform insulation-resistance test using megohm meter with voltage output of at least 2500 V. Individually test each conductor with other conductors and shields grounded. Test duration shall be 1 minute.

3) Perform DC high-potential test on cables, including terminations and joints after cable system installation and before placing cable in service. Adhere to precautions and limits as specified in applicable NEMA/ICEA Standards for the specific cable. Perform tests in accordance with ANSI/IEEE Standard 400. Test voltages shall not exceed 80% of cable manufacturer's factory test value or maximum test voltage in Table 6.

a) Insure input voltage to test set is regulated.

b) Current-sensing circuits in test equipment shall measure only leakage current associated with cable under test and shall not include internal leakage of test equipment.

c) Record wet- and dry-bulb temperatures or relative humidity and temperature.

d) Test each section of cable individually.

e) Individually test each conductor with other conductors grounded. Ground shields.

f) Terminations shall be adequately corona-suppressed by guard ring, field reduction sphere, or other suitable method as necessary.

g) Insure maximum test voltage does not exceed limits for terminators specified in ANSI/IEEE Standard 48 or manufacturer's specifications.

h) Apply DC high-potential test in at least 5 equal increments until maximum test voltage is reached. No increment shall exceed voltage rating of the cable. Record DC leakage current at each step after constant stabilization time consistent with system charging current.

i) Raise conductor to specified maximum test voltage and hold for 15 minutes on shielded cable and 5 minutes on non-shielded cable. Record readings of leakage current at 30 seconds and one minute and at one-minute intervals thereafter.

j) Reduce conductor test potential to zero and measure residual voltage at discrete intervals.

k) Apply grounds for time period adequate to drain insulation stored charge.

l) When new cables are spliced into existing cables, DC high-potential test shall be performed on new cable prior to splicing in accordance with this section. After test results are approved for new cable and splice is complete, perform insulation-resistance test and shield-continuity test on the length of new and existing cable including the splice. After satisfactory insulation-resistance test, DC high-potential test shall be performed on cable using test voltage acceptable to ANL and not exceeding 60% of factory test value.

c. Test Values:

1) Shielding must exhibit continuity. Investigate resistance values in excess of 10 ohms per 1000 ft of cable.

2) Graphic plots may be made of leakage current versus step voltage at each increment and leakage current versus time at final test voltages.

a) Step voltage slope should be reasonably linear.

b) Capacitive and absorption current should decrease continually until steady state leakage is approached.

3. Electrical Metering:

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with drawings and specifications.

2) Inspect physical and mechanical condition.

3) Verify tightness of electrical connections.

4) Inspect cover gasket, cover glass, condition of spiral spring, disc clearance, contacts, and case-shorting contacts, as applicable.

5) Verify freedom of movement, correct travel and alignment, and tightness of mounting hardware.

b. Electrical Tests:

1) Check calibration of meters at cardinal points.

2) Calibrate watt-hour meters according to manufacturer's published data.

3) Verify instrument multipliers.

4) Electrically confirm current transformer and voltage transformer secondary circuits are intact.

c. Electrical and Mechanical Tests:

1) Perform insulation-resistance test on generator winding with respect to ground in accordance with ANSI/IEEE Standard 43. Calculate polarization index.

2) Test protective relay devices in accordance with paragraph "Protective Relays."

3) Perform phase-rotation test to determine compatibility with load requirements.

4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.

5) Perform vibration baseline test. Plot amplitude versus frequency for each main bearing cap.

6) Conduct performance test in accordance with NFPA Standard 110, Section 7-13 (Installation Acceptance).

7) Verify correct functioning of governor and regulator.

8) Verify function and temperature regulation for battery and engine heaters.

d. Test Values:

1) Polarization index values shall be in accordance with ANSI/IEEE Standard 43.

2) Vibration levels shall be in accordance with manufacturer's published data.
3) Performance tests shall conform to manufacturer's published data and NFPA 110.
4) Vibration amplitudes shall not exceed values shown in Table 10.
5) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.

4. Dry Type Transformers (Small):
   a. Visual and Mechanical Inspection:
      1) Compare equipment nameplate data with drawings and specifications.
      2) Inspect physical and mechanical condition.
      3) Inspect anchorage, alignment, and grounding.
      4) Verify that resilient mounts are free and that any shipping brackets have been removed.
      5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
      6) Verify that as-lift tap connections are as specified.
   b. Electrical Tests:
      1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground with test voltage in accordance with Table 5. Calculate dielectric absorption ratio or polarization index.
   c. Test Values:
      1) Bolt-torque levels should be in accordance with Table 12, unless otherwise specified by manufacturer.
      2) Insulation-resistance test values at one minute should be in accordance with Table 5.
      3) The dielectric absorption or polarization index shall be greater than 1.0 and shall be recorded for future reference.
5. Dry Type Transformers (Large):
   a. Visual and Mechanical Inspection:
      1) Compare equipment nameplate data with drawings and specifications.
      2) Inspect physical and mechanical condition.
      3) Verify control and alarm settings on temperature indicators are as specified.
      4) Verify cooling fans operate correctly and fan motors have correct overcurrent protection.
      5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
      6) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."
      7) Perform specific inspections and mechanical tests as recommended by manufacturer.
      8) Make a close examination of shipping brackets or fixtures that may not have been removed during installation. Insure resilient mounts are free.
      9) Verify seismic bracing is correct.
      10) Verify winding core, frame, and enclosure grounding are correct.
      11) Verify as-lift tap connections are as specified.
   b. Electrical Tests:
      1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground with test voltage in accordance with Table 5.
      2) Calculate polarization index.

3) Perform power-factor or dissipation-factor tests in accordance with test equipment manufacturer's instructions.

4) Perform turns-ratio test on tap connections. Verify winding polarities are in accordance with nameplate.

5) Perform an excitation-current test on each phase.

6) Measure resistance of each winding at each tap connection.

7) Verify core is solidly grounded. If core is insulated and removable core ground strap is available, perform core insulation-resistance test at 500 VDC.

8) Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

9) Perform over-potential test on all high- and low-voltage windings-to-ground.

c. Test Values:

1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.

2) Insulation-resistance test values at one minute should not be less than values recommended in Table 5. Results shall be temperature corrected in accordance with Table 14.

3) Polarization index should be compared to manufacturer's factory test results. If manufacturer's data is not available, acceptance test results will serve as baseline data.

4) Turns-ratio test results should not deviate more than 0.5% from either adjacent coils or calculated ratio.

5) CH and CL dissipation-factor/power-factor values will vary due to support insulators and bus work used on dry transformers. The following should be expected on CHL power factors:

a) Power Transformers: 2% or less

b) Distribution Transformers: 5% or less

6) Consult transformer manufacturer's or test equipment manufacturer's data for additional information.

7) If winding-resistance test results vary more than 1% from adjacent windings, consult manufacturer.

8) Typical excitation current test data pattern for three-legged core transformer is two similar current readings and one lower current reading.

9) If core insulation resistance is less than one megohm at 500 VDC, consult manufacturer.

10) AC over-potential test shall not exceed 75% of factory test voltage for one minute duration. DC over-potential test shall not exceed 100% of factory RMS test voltage for one minute duration. Insulation shall withstand over-potential test voltage applied.

6. Liquid Filled Transformers:

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with drawings and specifications.

2) Inspect physical and mechanical condition for physical damage, cracked insulators, and tightness of connection.

3) Verify removal of shipping bracing after final placement.

4) Inspect impact recorder prior to unloading, if applicable.

5) Verify alarm, control, and trip settings on temperature and level indicators are as specified.

6) Verify cooling fans and pumps operate correctly and fans and pump motors have correct overcurrent protection.

7) Verify operation of alarm, control, and trip circuits from temperature and level indicators, pressure relief device, and fault pressure relay.

8) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.

9) Perform thermographic survey in accordance with paragraph "Thermographic Survey."

10) Verify correct liquid level in tanks and bushings.

11) Perform specific inspections and mechanical tests as recommended by manufacturer.

12) Verify correct equipment grounding.

b. Electrical Tests:

1) Perform insulation-resistance tests, winding-to-winding and each winding-to-grounding with test voltage in accordance with Table 5. Test duration shall be for 10 minutes with resistance tabulated at 30 seconds, 1 minute, and 10 minutes.

2) Calculate polarization index.

3) Perform a turns-ratio test on no-load tap-changer positions and load tap-changer positions. Verify tap setting is as specified. Verify winding polarities are in accordance with nameplate.

4) Perform insulation power-factor/dissipation-factor tests on windings and correct to 20°C in accordance with test equipment manufacturer's instructions.

5) Perform power-factor/dissipation-factor tests (or hot collar watts-loss tests) on bushings and correct to 20°C in accordance with test equipment manufacturer's instructions.

6) Perform excitation-current tests in accordance with test equipment manufacturer's instructions.

7) Measure resistance of each high-voltage winding in each no-load tap-changer position. Measure resistance of each low-voltage winding in each load tap-changer position, if applicable.

8) If core ground strap is accessible, measure core insulation resistance at 500 VDC.

9) Measure percentage of oxygen in nitrogen blanket.

10) Remove sample of insulating liquid in accordance with ASTM D923. Sample shall be tested for the following:

a) Dielectric breakdown voltage: ASTM D877 and/or ASTM D1816.

b) Acid neutralization number: ASTM D974.

c) Specific gravity: ASTM D1298.

d) Interfacial tension: ASTM D971 or ASTM D2285.

e) Color: ASTM D1500.

f) Visual condition: ASTM D1524.

g) Measure dissipation factor or power factor in accordance with ASTM D924.

11) Remove sample of insulating liquid in accordance with ASTM D3613 and perform dissolved gas analysis (DGA) in accordance with ANSI/IEEE C57.104 or ATSM D3612.

12) Test instrument transformers in accordance with paragraph "Instrument Transformers."

13) Test surge arresters in accordance with paragraph "Surge Arresters."

c. Test Values:

1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.

2) Insulation-resistance test values at one minute should not be less than values recommended in Table 5. Resistance values to be temperature corrected in accordance with Table 14.

3) Polarization index should be compared to manufacturer's factory test results. If manufacturer's data is not available, acceptance test results will serve as baseline data.

4) Turns-ratio test results shall not deviate more than 0.5% from either the adjacent coils or the calculated ratio.

5) Maximum power factor of liquid-filled transformers corrected to 20°C shall be in accordance with transformer manufacturer's published data. Representative values are shown in Table 3. Compare with test equipment manufacturer's published data.

6) Investigate bushing power factors and capacitances that vary from nameplate values by more than 10%. Investigate any bushing hot collar watts-loss results that exceed test equipment manufacturer's published data.

7) Typical excitation-current test data pattern for three-legged core transformer is two similar current readings and one lower current reading.

8) Consult manufacturer if winding-resistance measurements vary more than 1% from adjacent windings.

9) Consult manufacturer if core insulation is less than one megohm at 500 VDC.

10) Insulating liquid shall comply with Table 4.

11) Evaluate results of dissolved-gas analysis in accordance with IEEE Standard C57.104. Use results as baseline for future tests.

7. Low-Voltage Switchgear and Switchboard Assemblies:

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with drawings and specifications.

2) Inspect physical and mechanical condition.

3) Confirm correct application of manufacturer's recommended lubricants.

4) Verify appropriate anchorage, required area clearances, grounding and correct alignment.

5) Inspect doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

6) Verify fuse and/or circuit breaker sizes and types correspond to drawings and coordination study as well as to circuit breaker's address for microprocessor-communication packages.

7) Verify that current and potential transformer ratios correspond to drawings.

8) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench. Refer to manufacturer's published data or Table 12 for proper torque values.

9) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."

10) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

a) Attempt closure on locked-open devices. Attempt to open locked-closed devices.

b) Make key exchange with devices operated in off-normal positions.

11) Inspect insulators for evidence of physical damage or contaminated surfaces.

12) Verify correct barrier and shutter installation and operation.

13) Exercise active components.

14) Inspect mechanical indicating devices for correct operation.

15) Verify filters are in place and/or vents are clear.

16) Perform visual and mechanical inspection of instrument transformers, in accordance with paragraph "Instrument Transformers."

17) Inspect control power transformers.

a) Inspect physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.

b) Verify that primary and secondary fuse ratings or circuit breakers match drawings.

c) Verify correct functioning of draw-out disconnecting and grounding contacts and interlocks.

b. Electrical Tests:

1) Perform tests on all instrument transformers in accordance with paragraph "Instrument Transformers."

2) Perform resistance tests through bus joints with low-resistance ohmmeter. Joints that cannot be directly measured due to permanently installed insulation wrap shall be indirectly measured from closest accessible connection.

3) Perform insulation-resistance tests in each bus section, phase-to-phase and phase-to-ground for one minute in accordance with Table 1.

4) Perform over-potential test on each bus section, each phase-to-ground with phases not under test grounded, in accordance with manufacturer's published data. In the absence of any published data, Table 2 shall apply. Test voltage shall be applied for one minute.

5) Perform insulation-resistance tests at 1000 VDC on control wiring. Test duration shall be one minute. Do not perform this test on wiring connected to solid-state components. Follow manufacturer's recommendation.

6) Perform current injection tests on the entire current circuit in each section of switchgear.

   a) Perform current tests by primary injection, where possible, with magnitudes such that minimum of 1.0 amp flows in secondary circuit.

   b) Where primary injection is impractical, utilize secondary injection with minimum current of 1.0 amp.

   c) Test current at each device.

7) Determine accuracy of meters and calibrate watt-hour meters in accordance with paragraph "Electrical Metering." Verify multipliers.

8) Perform phasing check on double-ended switchboard/switchgear to insure correct bus phasing from each source.

9) Perform the following tests on control power transformers:

   a) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with Table 1 unless otherwise specified by manufacturer.

   b) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage. Confirm potential at all devices.

   c) Verify correct secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with secondary wiring disconnected.

   d) Verify correct function of control transfer relays located in switchboard/switchgear with multiple control power sources.

10) Potential Transformer Circuits:

   a) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be in accordance with Table 1, unless otherwise specified by manufacturer.

   b) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to correct secondary voltage.

   c) Verify secondary voltage by energizing primary winding with system voltage. Measure secondary voltage with secondary wiring disconnected.

11) Verify operation of switchgear/switchboard space heaters.

c. Test Values:

1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.

2) Compare bus connection resistances to values of similar connections.

3) Insulation-resistance values for bus, control wiring, and control power transformers shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 1. Values of insulation resistance less than this table or manufacturer's minimum should be investigated. Over-potential tests should not proceed until insulation-resistance levels are raised above minimum values.

4) Bus insulation shall withstand the over-potential test voltage applied.

5) Contact resistance values shall not exceed high limit of normal range as indicated in manufacturer's published data. If manufacturer's data is not available, investigate values that deviate from similar bus by more than 50% of lowest value.

8. Low-Voltage Power Circuit Breakers:

a. Visual and Mechanical Inspection:

1) Compare nameplate data with drawings and specifications.

2) Inspect physical and mechanical conditions.

3) Confirm correct application of manufacturer's recommended lubricants.

4) Inspect anchorage, alignment, and grounding.

5) Inspect arc chutes.

6) Inspect moving and stationary contacts for condition, wear, and alignment.

7) Verify maintenance devices are available for serving and operating breaker.

8) Verify primary and secondary contact wipe and other dimensions vital to satisfactory operation of breaker are correct.

9) Perform mechanical operator and contact alignment tests on breaker and its operating mechanism.

10) Verify tightness of accessible bolted bus connections by calibrated torque-wrench method. Refer to manufacturer's instructions or Table 12 for correct torque levels.

11) Perform thermographic survey of accessible bolted bus connections in accordance with paragraph "Thermographic Survey."

12) Check cell fit and element alignment.

13) Check racking mechanism.

14) Record as-found and as-left operation-counter readings.

b. Electrical Tests:

1) Perform contact-resistance test.

2) Perform insulation-resistance test at 1000 VDC from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase. Test duration shall be one minute. Use a minimum test voltage in accordance with Table 1 or manufacturer's published data.

3) Perform insulation-resistance test at 1000 VDC on control wiring. Test duration shall be one minute. Do not perform test on wiring connected to solid-state components. Follow manufacturer's recommendation.

4) Make adjustments for final trip settings in accordance with overcurrent protective device coordination study.

5) Determine minimum pickup current by primary current injection.

6) Determine long-time delay by primary current injection.

7) Determine short-time pickup and delay by primary current injection.

8) Determine ground-fault pickup and delay by primary current injection.

9) Determine instantaneous pickup value by primary current injection.

10) Verify trip unit calibrations by secondary injection.

11) Activate auxiliary protective devices, such as ground-fault or undervoltage relays, to insure operation of shunt trip devices. Check operation of electrically operated breakers in their cubicles. Perform minimum operation voltage on shunt trip and close coils in accordance with Table 20.

12) Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrically close and trip operations, trip-free, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators.

13) Check charging mechanism.

14) Determine minimum operation voltage on shunt trip and close coils in accordance with Table 20.

c. Test Values:

1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.

2) Compare microhm or millivolt drop values to adjacent poles or similar breakers. Investigate deviations of more than 50% of the lowest value. Investigate any value exceeding manufacturer's recommendations.

3) Circuit breaker insulation resistance shall be in accordance with Table 1.

4) Control wiring insulation-resistance shall comply with manufacturer's published data. In the absence of manufacturer's published data, use Table 1. Values of insulation-resistance less than this table or manufacturer's minimum shall be investigated.

5) Trip characteristics of breakers shall fall within manufacturer's published time-current tolerance bands.

6) Minimum operation voltages on shunt trip and close coils shall be in accordance with manufacturer's published data. In the absence of manufacturer's data, refer to Table 20.

9. Low-Voltage Insulated-Case/Molded-Case Circuit Breakers, 225A and Larger:

a. Visual and Mechanical Inspection:

1) Compare nameplate date with drawings and specifications.

2) Inspect circuit breaker for correct mounting.

3) Check cell fit, element alignment and racking mechanism for draw-out breakers.

4) Operate circuit breaker to insure smooth operation.

5) Inspect case for cracks or other defects.

6) Verify tightness of accessible bolted electrical connections and/or cable connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.

7) Inspect mechanism contacts and arc chutes in unsealed units.

b. Electrical Tests:

1) Perform a contact-resistance test.

2) Perform insulation-resistance test at 1000 VDC from pole-to-pole and from each pole-to-ground with breaker closed and across open contacts of each phase. Test duration shall be one minute. Use a minimum test voltage in accordance with Table 1 or manufacturer's published data.

3) Perform insulation-resistance test at 1000 VDC on all control wiring. Test duration shall be one minute. Do not perform the test on wiring connected to solid-state components. Follow manufacturer's recommendation.

4) Perform adjustments for final trip settings in accordance with overcurrent protective device coordination study.

5) Perform long-time delay time-current characteristic tests by passing 300% rated current through each pole separately, unless series testing is required to defeat ground fault functions.

6) Determine short-time pickup and delay by primary current injection.

7) Determine ground-fault pickup and time delay by primary current injection.

8) Determine instantaneous pickup current by primary injection using run-up or pulse method.

9) Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

10) Verify trip unit calibrations by secondary injection.

11) Determine minimum operation voltage on shunt trip and close coils in accordance with Table 20.

12) Check charging mechanism.

c. Test Values:

1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.

2) Compare microhm or millivolt drop values to adjacent poles or similar breakers. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.

3) Circuit breaker insulation-resistance shall be in accordance with Table 1.

4) Control wiring insulation-resistance shall comply with manufacturer's published data. In the absence of manufacturer's published data, use Table 1. Values of insulation resistance less than this table or manufacturer's minimum shall be investigated.

5) Trip characteristic of breakers shall fall within manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are not available, trip times shall not exceed the value shown in Table 7. Circuit breakers exceeding specified trip time at 300% of pickup shall be tagged defective.

6) For molded-case circuit breakers, instantaneous pickup values shall be within manufacturer's published data or tolerances shown in Table 8.

7) Minimum operation voltages on shunt trip and close coils shall be in accordance with manufacturer's published data. In the absence of manufacturer's data, refer to Table 20.

10. Low-Voltage Disconnect Switches:

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with drawings and specifications.

2) Inspect physical and mechanical condition.

3) Inspect anchorage, alignment, grounding, and required clearances.

4) Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.

5) Verify that fuse sizes and types are in accordance with drawings, short-circuit and overcurrent protective device coordination studies.

6) Verify that each fuse has adequate mechanical support and contact integrity.

7) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.

8) Perform thermographic survey of accessible bolted electrical connection in accordance with paragraph "Thermographic Survey."

9) Verify operation and sequencing of interlocking systems.

10) Verify correct phase barrier installation.

11) Verify correct operation of all indicating and control devices.

12) Confirm correct application of manufacturer's recommended lubricants.

b. Electrical Tests:

1) Measure contact resistance across each switchblade and fuseholder.

2) Perform insulation-resistance test at 1000 VDC from pole-to-pole and from each pole-to-ground. Test duration shall be one minute. Use a minimum test voltage in accordance with Table 1 or manufacturer's published data.

3) Measure fuse resistance.

4) Perform ground fault test, if applicable.

c. Test Values:

1) Compare bolted connection resistances to values of similar connections.

2) Bolt-torque levels should be in accordance with Table 12, unless otherwise specified by the manufacturer.

3) Compare microhm or millivolt drop values to adjacent poles or similar switches. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.

4) Minimum insulation-resistance shall be in accordance with manufacturer's published data or Table 1.

5) Investigate fuse-resistance values that deviate from each other by more than 15%.

11. Automatic Transfer Switches:

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with drawings and specifications.

2) Inspect physical and mechanical condition.

3) Confirm correct application of manufacturer's recommended lubricants.

4) Verify manual transfer warnings are attached and visible.

5) Verify tightness of control connections.

6) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.

7) Perform thermographic survey of accessible bolted electrical connections in accordance with paragraph "Thermographic Survey."

8) Perform manual transfer operation.

9) Verify positive mechanical interlocking between normal and alternative sources.

10) Inspect anchorage, alignment, grounding and required clearances.

b. Electrical Tests:

1) Measure contact resistance.

2) Perform insulation-resistance tests, phase-to-phase and phase-to-ground, with switch in both source positions. Test duration shall be one minute. Use a test voltage in accordance with Table 1 or manufacturer's published data. For control devices that cannot tolerate test voltage, follow manufacturer's recommendation.

3) Verify settings and operation of control devices.

4) Calibrate and set relays and timers in accordance with paragraph "Protective Relays."

5) Verify phase rotation, phasing and synchronized operation as required by the application.

6) Perform automatic transfer tests:

a) Simulate loss of normal power.

b) Return to normal power.

c) Simulate loss of emergency power.

d) Simulate all forms of single-phase conditions.

7) Verify correct operation and timing of following functions:

a) Normal source voltage-sensing relays.

b) Engine start sequence.
c) Time delay upon transfer.
d) Alternate source voltage-sensing relays.
e) Automatic transfer operation.
f) Interlocks and limit switch function.
g) Time delay and retransfer upon normal power restoration.
h) Engine cool down and shutdown feature.

c. Test Values:
1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.
2) Insulation-resistance test voltage and minimum values shall be in accordance with Table 1.
3) Compare microhm values to adjacent poles or similar switches. Investigate deviations of more than 50% of lowest value. Investigate any value exceeding manufacturer's recommendations.

12. Motor Control
a. Visual and Mechanical Inspection:
1) Compare equipment nameplate data with drawings and specifications.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment and grounding.
4) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
5) Verify controller mechanical operations. Inspect gap, wipe, alignment, and pressure are in accordance with manufacturer's published data.
6) Verify motor running protection installed and properly sized.
7) Confirm correct application of manufacturer's recommended lubricants.

b. Electrical Tests:
1) Perform resistance tests through all bus joints with low-resistance ohmmeter. Any joints that cannot be directly measured due to permanently installed insulation wrap shall be indirectly measured from closest accessible connection.
2) Perform insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground with controller closed and across each open pole. Test duration shall be one minute. Use a test voltage in accordance with Table 1 or manufacturer's published data. For control devices that cannot tolerate test voltage, follow manufacturer's recommendations.
3) Perform insulation-resistance tests at 1000 VDC on control wiring. Test duration shall be one minute. Do not perform this test on wiring connected to solid-state components. Follow manufacturer's recommendations.
4) Test motor protection devices in accordance with manufacturer's published data. In the absence of manufacturer's data, use paragraph "Protective Relays."
5) Test circuit breakers in accordance with paragraph "Low-Voltage Insulated-Case/Molded-Case Circuit Breakers."
6) Perform operational tests by initiating control devices.

c. Test Values:
1) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.
2) Compare bus connection resistances to values of similar connections.

3) Insulation-resistance values for bus, control wiring, and control power transformers shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 1. Values of insulation-resistance less than this table or manufacturer's minimum should be investigated.

4) Motor protection parameters shall be in accordance with manufacturer's published data.

13. Ground Fault Protection Systems:

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with drawings and specifications.

2) Visually inspect components for damage and errors in polarity or conductor routing:

a) Verify ground connection is made ahead of neutral disconnect link and on line side of any ground fault sensor.

b) Verify neutral sensors are connected with correct polarity on both primary and secondary.

c) Verify all phase conductors and neutral pass through sensor in same direction for zero sequence systems.

d) Verify grounding conductors do not pass through zero sequence sensors.

e) Verify grounded conductor is solidly grounded.

3) Verify tightness of accessible bolted electrical connections, including control circuits, by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.

4) Verify correct operation of self-test panel.

5) Set pickup and time-delay settings in accordance with settings provided on drawings and in specifications. Record operation and test sequences as required by NFPA 70.

6) Verify the control power transformer has adequate capacity for the system.

b. Electrical Tests:

1) Measure system neutral-to-ground insulation resistance with neutral disconnect link temporarily removed. Replace neutral disconnect link after testing.

2) Perform insulation-resistance test of control wiring at 1000 VDC for one minute. Do not perform this test on wiring connected to solid-state components. Follow manufacturer's recommendations.

3) Perform the following pickup tests using primary injection:

a) Verify relay does not operate at 90% of pickup setting.

b) Verify pickup is less than 125% of setting or 1200 amp, whichever is smaller.

4) For summation type systems using phase-neutral current transformers, verify correct polarities by applying current to each phase-neutral current transformer pair. This test also applies to molded-case breakers using external neutral current transformer.

a) Relay should operate when current direction is the same relative to polarity marks in the two current transformers.

b) Relay should not operate when current direction is opposite relative to polarity marks in the two current transformers.

5) Measure time delay of the relay at 150% or greater of pickup.

6) Verify reduced voltage tripping capability: 55% for AC systems and 80% for DC systems.

c. Test Values:

1) System neutral-to-ground insulation shall be minimum of one megohm.

2) Insulation resistance values shall be in accordance with Table 1.

3) Relay timing shall be in accordance with manufacturer's specifications but must also be no longer than one second at 3000 amp.

4) Bus bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by manufacturer.

14. Grounding Systems:
    a. Visual and Mechanical Inspection:
        1) Verify ground system is in compliance with drawings, specifications, and NFPA 70.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage.
    b. Electrical Tests:
        1) Perform fall-of-potential or alternative test in accordance with ANSI/IEEE 81 on the main grounding electrode or system.
        2) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.
        3) Make resistance measurements in dry weather not earlier than 48 hours after rainfall.
    c. Test Values:
        1) The resistance between the main grounding electrode and ground should be no greater than five ohms. (Reference ANSI/IEEE 142.) Investigate any values above five ohms and notify Engineer immediately for further instructions.
        2) Investigate point-to-point resistance values that exceed 0.5 ohm.
15. Instrument Transformers:
    a. Visual and Mechanical Inspection:
        1) Compare equipment nameplate data with drawings and specifications.
        2) Inspect physical and mechanical condition.
        3) Verify correct connection of transformers with system requirements.
        4) Verify adequate clearance between primary and secondary circuit wiring.
        5) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or Table 12.
        6) Perform thermographic survey of bolted electrical connections in accordance with paragraph "Thermographic Survey."
        7) Verify required grounding and shorting connections provide contact.
        8) Verify correct operation of transformer withdrawal mechanism and grounding operation.
        9) Verify correct primary and secondary fuse sizes for potential transformers.
        10) Confirm correct application of manufacturer's recommended lubricants.
    b. Electrical Tests – Current Transformers:
        1) Perform insulation-resistance test of current transformer and wiring-to-ground at 1000 VDC. Do not perform this test on wiring connected to units with solid-state components. Follow manufacturer's recommendations.
        2) Perform polarity test of each current transformer.
        3) Perform ratio-verification test using voltage or current method in accordance with ANSI/IEEE C57.13.1.
        4) Perform excitation test on transformers used for relaying applications in accordance with ANSI/IEEE C57.13.1.
        5) Measure current circuit burdens at transformer terminal and determine total burden.
        6) When applicable, perform insulation-resistance and dielectric withstand tests on primary winding with secondary grounded. Test voltages shall be in accordance with Tables 5 and 9 respectively.

7) Verify that current circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3.

c. Electrical Tests – Voltage Transformers:

1) Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute in accordance with Table 5. For units with solid-state components, follow manufacturer's recommendation.

2) Perform polarity test on each transformer to verify polarity marks or H1-X1 relationship as applicable.

3) Perform turns ratio test on all tap positions, if applicable.

4) Measure potential circuit burdens at transformer terminals and determine total burden.

5) Perform dielectric withstand test on primary windings with secondary windings connected to ground. Dielectric voltage shall be in accordance with Table 9. Test voltage shall be applied for one minute.

d. Test Values:

1) Insulation-resistance measurement on instrument transformer shall not be less than that shown in Table 5.

2) Bolt-torque levels shall be in accordance with Table 12, unless otherwise specified by the manufacturer.

3) Polarity results shall agree with system drawings.

4) Compare measured burdens to calculated burdens supplied by ANL.

5) Ratio accuracies shall be within 0.5% of nameplate or manufacturer's published data.

6) Insulation shall withstand over-potential test voltage applied.

B. Test Reports:

1. Testing firm shall do the following:

a. Prepare test report, including description of equipment tested, description of test, test results, conclusions and recommendations, retesting results, list of test equipment used and calibration date.

b. Show test results in comparison to industry and manufacturer's values and tolerances.

c. Interpret test results in writing and give recommendations for acceptance or rejection upon consultation with Engineer and prior to energizing equipment.

d. Assure electrical equipment is operational and within industry and manufacturer's tolerances, and is installed in accordance with contract documents.

e. Assure suitability of energization.

f. Report to the ANL and Engineer any system, material, or workmanship that is found defective on the basis of acceptance tests.

g. Retest equipment when required.

h. Maintain written record of tests.

i. Utilize safety practices during the tests in accordance with:

1) Acceptable state and local safety operating procedures.

2) ANL's safety practices.

3) OSHA.

4) NFPA 70E.

j. Perform tests with apparatus de-energized and grounded, except where otherwise specifically required ungrounded by test procedures.

k. Assemble and certify final test report.

l. Provide 4 copies of complete test report.

m. Attach label to all tested equipment with indication of date tested and testing firm name.

2. Contractor shall do the following:
   a. Investigate, replace, or repair any fault in material or in any part of the installation revealed by the tests.
   b. Deliver one copy of each test report directly to Engineer within 30 days after completion of testing, unless directed otherwise. Insert a copy of each test report in the equipment operation and maintenance manuals.

C. Test Equipment:
   1. Test Instrument Calibration:
      a. Testing firm shall have calibration program that assures test instruments are maintained with rated accuracy.
      b. Instruments shall be calibrated in accordance with the following frequency schedule:
         1) Field instruments: Analog, 6 months maximum; Digital, 12 months maximum
         2) Laboratory instruments: 12 months
         3) Leased specialty equipment: 12 months where accuracy is guaranteed by lessor
      c. Dated calibration labels shall be visible on test equipment.
      d. Records, which show date and results of instruments calibrated or tested, must be kept up-to-date.
      e. Up-to-date instrument calibration instructions and procedures shall be maintained for test instrument.
      f. Equipment used for field testing shall be more accurate than instrument being tested.
      g. Calibrating standard applied to testing equipment shall be of higher accuracy than instrument tested.

3.3 STARTUP

A. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

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SECTION 26 08 13

POWER DISTRIBUTION ACCEPTANCE TEST TABLES

TABLE 1
Insulation Resistance Test Values
Electrical Apparatus And Systems

Voltage Rating	Minimum DC Test Voltage	Recommended Minimum Insulation Resistance In Megohms
250	500	25
600	1,000	100
1,000	1,000	100
2,500	1,000	500
5,000	2,500	1,000
8,000	2,500	2,000
15,000	2,500	5,000
25,000	5,000	20,000
34,500 and above	15,000	100,000

See Table 14 for temperature correction factors.

TABLE 2
Switchgear Low-Frequency Withstand Test Voltages

Type of Switchgear	Rated kV	Maximum Test Voltage kV	
		AC	DC
Low-Voltage Power Circuit Breaker Switchgear	.254	1.6	2.3
	.508	1.6	2.3
	.635	1.6	2.3
MC (Metal-Clad Switchgear)	4.76	14.0	20.0
	8.25	27.0	37.0
	15.0	27.0	37.0
	27.0	45.0	+
	38.0	60.0	+
SC (Station-Type Cubicle Switchgear)	15.5	37.0	+
	38.0	60.0	+
	72.5	*120*.0	+
MEI (Metal-Enclosed Interrupter Switchgear)	4.76	14.0	20.0
	8.25	19.0	27.0
	15.0	27.0	37.0
	15.5	37.0	52.0
	25.8	45.0	+
	38.0	60.0	+

Derived from ANSI/IEEE C37.20.2-1993, Paragraph 5.5, *Metal-Clad and Station-Type Cubicle Switchgear* and C37.20.3-1993, Paragraph 5.5, *Metal-Enclosed Interrupter Switchgear*, and includes 0.75 multiplier with fraction rounded down.

The column headed “DC, Maximum Test Voltage kV” is given as a reference only for those using DC tests to verify the integrity of connected cable installations without disconnecting the cables from the switchgear. It represents values believed to be appropriate and approximately equivalent to the corresponding power frequency withstand test values specified for voltage rating of switchgear. The presence of this column in no way implies any requirement for a DC withstand test on AC equipment or that a DC withstand test represents an acceptable alternative to the low-frequency withstand tests specified in this specification, either for design tests, production tests, conformance tests, or field tests. When making DC tests, the voltage should be raised to the test value in discrete steps and held for a period of one minute.

Because of the variable voltage distribution encountered when making DC withstand tests, the manufacturer should be contacted for recommendations before applying DC withstand tests to the switchgear. Voltage transformers above 34.5kV should be disconnected when testing with DC. Refer to ANSI/IEEE C57-13-1993 (*IEEE Standard Requirements for Instrument Transformers*) paragraph 8.8.2.
+ Consult Manufacturer

TABLE 5

Transformer Insulation-Resistance
Acceptance Test Voltage and Minimum Results

Transformer Coil Rating Type in Volts	Minimum DC Test Voltage	Recommended Minimum Insulation Resistance in Megohms	
		Liquid Filled	Dry
0 - 600	1000	100	500
601 - 5000	2500	1000	5000
5001 - 15000	5000	5000	25000

See Table 14 for Temperature Correction Factors.

NOTE: Since insulation resistance depends on insulation rating (kV) and winding capacity (kVA), values obtained should be compared to manufacturer's test data.

TABLE 6
Medium-Voltage Cables
Acceptance Test Values

Table 6.1
DC Test Voltages

Rated Voltage Phase-to-Phase kV	Conductor Sizes AWG or kcmil (mm)	Nominal Insulation Thickness mils (mm)		Maximum DC Field Test Voltages, kV During/After Installation	
		100% Insulation Level	133% Insulation Level	100% Insulation Level	133% Insulation Level
5	8-1000 (8.4-507) Above 1000 (507)	90 (2.29) 140 (3.56)	115 (2.92) 140 (3.56)	28 28	36 36
8	6-1000 (13.3-507) Above 1000 (507)	115 (2.92) 175 (4.45)	140 (3.56) 175 (4.45)	36 36	44 44
15	2-1000 (33.6-507) Above 1000 (507)	175 (4.45) 220 (5.59)	220 (5.59) 220 (5.59)	56 56	64 64
25	1-2000 (42.4-1013)	260 (6.60)	320 (8.13)	80	96
28	1-2000 (42.4-1013)	280 (7.11)	345 (8.76)	84	100
35	1/0-2000 (53.5-1013)	345 (8.76)	420 (10.7)	100	124

Tables derived from ANSI/ICEA S-93-639/NEMA WC 74-2000, *5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy;* ANSI/ICEA S-94-649-2000, *Standard for Concentric Neutral Cables Rated 5,000 – 46,000 Volts*; ANSI/ICEA S-97-682-2000, *Standard for Utility Shielded Power Cables Rated 5,000 – 46,000 Volts*; and The Okonite Company, *High-Voltage Proof Testing*.

The DC field test voltages listed above are intended for cable designed in accordance with ICEA specifications. When older cables or other types/classes of cables or accessories are connected to the system, voltages lower than those shown may be necessary. Consult the manufacturers of the cables and/or accessories before applying the test voltage.

TABLE 6 (CONT.)
Medium-Voltage Cables
Acceptance Test Values

Table 6.2 AC Test Voltages					
		Nominal Insulation Thickness mils (mm)		AC Test Voltage, kV	
Rated Voltage Phase-to-Phase kV	Conductor Sizes AWG or kcmil (mm)	100% Insulation Level	133% Insulation Level	100% Insulation Level	133% Insulation Level
5 KV	8-1000 1001-3000	90 (2.29) 140 (3.56)	115 (2.92) 140 (3.56)	18 28	23 28
8 kV	6-1000 1001-3000	115 (2.92) 175 (4.45)	140 (3.56) 175 (4.45)	23 35	28 35
15 kV	2-1000 1001-3000	175 (4.45) 220 (5.59)	220 (5.59) 220 (5.59)	35 44	44 44
25 kV	1-3000	260 (6.60)	320 (8.13)	52	64
28 kV	1-3000	280 (7.11)	345 (8.76)	56	69
35 kV	1/0-3000	345 (8.76)	420 (10.7)	69	84

Tables derived from ANSI/ICEA S-93-639/NEMA WC 74-2000, *5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy;* ANSI/ICEA S-94-649-2000, *Standard for Concentric Neutral Cables Rated 5,000 – 46,000 Volts*; ANSI/ICEA S-97-682-2000, *Standard for Utility Shielded Power Cables Rated 5,000 – 46,000 Volts.*

All AC voltages are RMS values.

TABLE 6 (CONT.)
Medium-Voltage Cables
Acceptance Test Values

Table 6.3 Partial Discharge Requirements for Semiconducting Coating and Tape Designs Only		
Rated Circuit Voltage Phase-to-Phase Volts	Minimum Partial Discharge Extinction Level, kV	
	100% Insulation Level	133% Insulation Level
2001-5000	4	5
5001-8000	6	8
8001-15000	11	15

ANSI/ICEA S-93-639/NEMA WC 74-2000, *5-56 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.*

Table 6.4 Very Low Frequency Testing Levels 0.1 Hz Test Voltage (RMS)	
System Voltage Phase-to-Phase (kV) (RMS)	Proof Phase-to-Ground (kV) (RMS)
5	10
15	22
25	33
35	47

TABLE 7
Molded-Case Circuit Breakers
Values for Inverse Time Trip Test

(At 300% of Rated Continuous Current of Circuit Breaker)

Range of Rated Continuous Current Amperes	Maximum Trip Time in Seconds For Each Maximum Frame Rating[1]	
	250V	251 - 600V
0-30	50	70
31-50	80	100
51-100	140	160
101-150	200	250
151-225	230	275
226-400	300	350
401-600	----------	450
601-800	----------	500
801-1000	----------	600
1001-1200	----------	700
1201-1600	----------	775
1601-2000	----------	800
2001-2500	----------	850
2501-5000	----------	900

Reproduction of Table 5-3 from NEMA Standard AB4-1996.

[1] For integrally-fused circuit breakers, trip times may be substantially longer if tested with the fuses replaced by solid links (shorting bars).

TABLE 8
Instantaneous Trip Setting Tolerances for Field Testing
of Marked Adjustable Trip Circuit Breakers

	Tolerances of High and Low Settings	
Ampere Rating	High	Low
Adjustable	+40%	-30%
Non-adjustable	+25%	-25%

Reproduction of Table 5-4 from NEMA publication AB4-1996.

For circuit breakers with nonadjustable instantaneous trips, tolerances apply to the manufacturer's published trip range, i.e., +40% on high side, -30% on low side.

TABLE 11
Overpotential Test Voltages for Electrical Apparatus Other than Inductive Equipment

Nominal System (Line) Voltage[1] (kV)	Insulation Class	AC Factory Test (kV)	Maximum Field Applied AC Test (kV)	Maximum Field Applied DC Test (kV)
1.2	1.2	10	6.0	8.5
2.4	2.5	15	9.0	12.7
4.8	5.0	19	11.4	16.1
8.3	8.7	26	15.6	22.1
14.4	15.0	34	20.4	28.8
18.0	18.0	40	4.0	33.9
25.0	25.0	50	30.0	42.4
34.5	35.0	70	42.0	59.4
46.0	46.0	95	57.0	80.6
69.0	69.0	140	84.0	118.8

[1] Intermediate voltage ratings are placed in the next higher insulation class.

TABLE 12

U.S. Standard

Bolt Torques for Bus Connections
Heat-Treated Steel – Cadmium or Zinc Plated

Grade	SAE 1 & 2	SAE 5	SAE 7	SAE 8
Minimum Tensile (PSI)	64K	105K	133K	150K
Bolt Diameter In Inches	Torque (Foot Pounds)			
1/4	4	6	8	8
5/16	7	11	15	18
3/8	12	20	27	30
7/16	19	32	44	48
1/2	30	48	68	74
9/16	42	70	96	105
5/8	59	96	135	145
3/4	96	160	225	235
7/8	150	240	350	380
1.0	225	370	530	570

Bolt Torques for Bus Connections
Silicon Bronze Fasteners[1]
Torque (Foot-Pounds)

Bolt Diameter in Inches	Nonlubricated	Lubricated
5/16	15	10
3/8	20	14
1/2	40	25
5/8	55	40
3/4	70	60

[1] Bronze alloy bolts shall have a minimum tensile strength of 70,000 psi.

TABLE 12 (CONT.)

Bolt Torques for Bus Connections
Aluminum Alloy Fasteners[2]
Torque (Foot Pounds)

Bolt Diameter in Inches	Lubricated
5/16	8.0
3/8	11.2
1/2	20.0
5/8	32.0
3/4	48.0

[2] Aluminum alloy bolts shall have a minimum tensile strength of 55,000 psi.

Bolt Torques for Bus Connections
Stainless Steel Fasteners[3]
Torque (Foot Pounds)

Bolt Diameter in Inches	Uncoated
5/16	14
3/8	25
1/2	45
5/8	60
3/4	90

[3] Bolts, cap screws, nuts, flat washers, locknuts: 18-8 alloy.
Belleville washers: 302 alloy.

TABLE 14
Insulation Resistance Conversion Factors For
Conversion of Test Temperature to 20°C

Temperature		Multiplier	
°C	°F	Apparatus Containing Immersed Oil Insulations	Apparatus Containing Solid Insulations
0	32	0.25	0.40
5	41	0.36	0.45
10	50	0.50	0.50
15	59	0.75	0.75
20	68	1.00	1.00
25	77	1.40	1.25
30	86	1.98	1.58
35	95	2.80	2.00
40	104	3.95	2.50
45	113	5.60	3.15
50	122	7.85	3.98
55	131	11.20	5.00
60	140	15.85	6.30
65	149	22.40	7.90
70	158	31.75	10.00
75	167	44.70	12.60
80	176	63.50	15.80

TABLE 19
Overpotential Test Voltages
Electrical Apparatus Other than Inductive Equipment

Nominal System (Line) Voltage[a] (kV)	Insulation Class	AC Factory Test (kV)	Maximum Field Applied AC Test (kV)	Maximum Field Applied DC Test (kV)
1.2	1.2	10	6.0	8.5
2.4	2.5	15	9.0	12.7
4.8	5.0	19	11.4	16.1
8.3	8.7	26	15.6	22.1
14.4	15.0	34	20.4	28.8
18.0	18.0	40	24.0	33.9
25.0	25.0	50	30.0	42.4
34.5	35.0	70	42.0	59.4

a. Intermediate voltage ratings are placed in the next higher insulation class.

TABLE 20
Rated Control Voltages and their Ranges
for Circuit Breakers

The maximum voltage is measured at the point of user connection to the circuit breaker [see Notes (9) (10)] with no operating current flowing, and the minimum voltage is measured with maximum operating current flowing.

Rated Control Voltages and their Ranges for Circuit Breakers					
RATED CONTROL VOLTAGE (8)	Direct Current Voltage Ranges (1)(2) Volts, DC		OPENING FUNCTIONS ALL TYPES	RATED CONTROL VOLTAGE (60 Hz)	ALTERNATING CURRENT (1)(2)(3)(5) CLOSING, TRIPPING, AND AUXILIARY FUNCTIONS
	CLOSING AND AUXILIARY FUNCTIONS				
	INDOOR CIRCUIT BREAKERS	OUTDOOR CIRCUIT BREAKERS		SINGLE PHASE	SINGLE PHASE
24	---	---	14-28	120	104-127 (4)
48	38-56	36-56	28-56	240	208-254 (4)
125	100-140	90-140	70-140	Polyphase	Polyphase
250	200-280	180-280	140-280		
---	---	---	---	208Y/120	180Y/104-220Y/127
---	---	---	---	240	208-254

Derived from Table 8, ANSI C37.06-2000, *AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis – Preferred Ratings and Related Required Capabilities.*

RATED CONTROL VOLTAGES AND THEIR RANGES FOR CIRCUIT BREAKERS Solenoid-Operated Devices	
RATED VOLTAGE	Closing Voltage Ranges for Power Supply
125 DC	90 – 115 or 105 – 130
250 DC	180 – 230 or 210 – 260
230 AC	190 – 230 or 210 - 260

Notes:

(1) Electrically operated motors, contactors, solenoids, valves, and the like need not carry a nameplate voltage rating that corresponds to the control voltage rating shown in the table as long as these components perform the intended duty cycle (usually intermittent) in the voltage range specified.

(2) Relays, motors, or other auxiliary equipment that function as a part of the control for a device shall be subject to the voltage limits imposed by this standard, whether mounted at the device or at a remote location.

(3) Includes supply for pump or compressor motors. Note that rated voltages for motors and their operating ranges are covered by ANSI/NEA MG-1-1978.

(4) Includes heater circuits.

(5) Voltage ranges apply to all closing and auxiliary devices when cold. Breakers using standard auxiliary relays for control functions may not comply at lower extremes of voltage ranges when relay coils are hot, as after repeated or continuous operation.

(6) Direct current control voltage sources, such as those derived from rectified alternating current, may contain sufficient inherent ripple to modify the operation of control devices to the extent that they may not function over the entire specified voltage ranges.

(7) This table also applies for circuit breakers in gas-insulation substation installations.

(8) In cases where other operational ratings are a function of the specific control voltage applied, tests in C37.09 may refer to the "Rated Control Voltage." In these cases, tests shall be performed at the levels in this column.

(9) For an outdoor circuit breaker, the point of user connection to the circuit breaker is the secondary terminal block point at which the wires from the circuit breaker operating mechanism components are connected to the user's control circuit wiring.

(10) For an indoor circuit breaker, the point of user connection to the circuit breaker is either the secondary disconnecting contact (where the control power is connected from the stationary housing to the removable circuit breaker), or the terminal block point in the housing nearest to the secondary disconnecting contact.

(11) Some solenoid operating mechanisms are not capable of satisfactory performance over the range of voltage specified in the standard; moreover, two ranges of voltage may be required for such mechanisms to achieve an acceptable standard of performance.

(12) The preferred method of obtaining the double range of closing voltage is by use of tapped coils. Otherwise, it will be necessary to designate one of the two closing voltage ranges listed above as representing the condition existing at the device location due to battery or lead voltage drop or control power transformer regulation. Also, caution should be exercised to ensure that the maximum voltage of the range used is not exceeded.

End of Section

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SECTION 26 09 13

ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 00 00 – General Electrical Requirements

B. Section 26 05 53 – Electrical Systems Identification

C. Section 26 23 00 - Low-Voltage Switchgear

D. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

E. Section 26 05 26 – Grounding and Bonding for Electrical Systems

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes equipment for energy and demand metering of unit equipment as shown on the drawings. It also includes options that provide for monitoring of demand at a remote location.

1.4 REFERENCE STANDARDS

A. ANSI C12.1 – Code for Electricity Metering

B. ANSI C12.7 – Requirements For Watthour Meter Sockets

C. ANSI C12.9 – Test Switches For Transformer-Rated Meters

D. ANSI C12.10 – Watthour Meters

E. ANSI C12.20 – Electricity Meters-0.2 and 0.5 Accuracy Classes

F. NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting

G. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)

H. NFPA 70 – National Electrical Code

I. UL 50 – Standard for Enclosures for Electrical Equipment (1995)

J. UL 414 – Standard for Meter Sockets (1999)

K. UL 467 – Grounding and Bonding Equipment

L. UL 486A-486B – Wire Connectors

1.5 SUBMITTALS

A. Product Data: For metering equipment, components and accessories indicated:
   1. Include data on features, components, and complete description; submit catalog cut sheets showing electrical characteristics and ratings.
   2. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Describe operating sequences, both automatic and manual.

B. Shop Drawings:
   1. Dimensioned plans and sections or elevation layouts.
   2. Wiring Diagrams: Power, signal, and control wiring. Identify terminals and wiring designations and color codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field installed wiring, and show circuit protection features.

C. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

D. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

E. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations and ratings of metering equipment on single-line diagrams and plan layouts.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include manufacturer's written instructions for testing.
      c. Include spare parts data listing, source, and current prices of replacement parts and supplies.
      d. Include manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

1.6 QUALITY ASSURANCE

A. Obtain metering equipment from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Receive, store, and handle modular meter center as specified in NECA 400. Use factory installed lifting provisions. Handle carefully to avoid damage to assembly internal components, enclosure, and finish.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.9 MAINTENANCE

A. Extra Materials: Furnish extra materials described below that match product installed, are packaged with protective covering for storage, and are identified with labels describing contents.
   1. Potential Transformer Fuses: Equal to 10% of amount installed for each size and type, minimum of 2 of each size and type.
   2. Control-Power Fuses: Equal to 10% of amount installed for each size and type, minimum of 2 of each size and type.
   3. Fuses for Fused Switches: Equal to 10% of amount installed for each size and type, minimum of 3 of each size and type.

PART 2 - PRODUCTS

2.1. EQUIPMENT FOR ELECTRICAL METERING

A. The paragraphs below describe meters installed in switchgear, distribution panels or separate enclosures at branch circuit panelboards. The equipment has remote reporting and control capability. The interconnect of this equipment and peripheral devices is not covered in Division 26. Refer to Section 23 09 01.

B. Switchgear Metering
   1. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
   2. Manufacturers:
      a. Square D
      b. General Electric
      c. Siemens
      d. Cutler-Hammer
      e. Approved equal
   3. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
      a. Phase Currents, Each Phase: +/-0.5%
      b. Phase-to-Phase Voltages, Three Phase: +/-1%
      c. Phase-to-Neutral Voltages, Three Phase: +/-1%
      d. Megawatts: +/-2%
      e. Megavars: +/-2%
      f. Power Factor: +/-2%
      g. Frequency: +/-0.5%
      h. Megawatt Demand: +/-2%; demand interval programmable from 5 to 60 minutes
      i. Accumulated Energy, Megawatt Hours: +/-2%. Accumulated values unaffected by power outages up to 72 hours
      j. Maximum demand (measure of average power demand over a 15-minute period) continuously recorded over a one-year period.
      k. Total Harmonic Distortion, Amperes
      l. Total Harmonic Distortion, Volts
      m. Individual Amperage Harmonics through the 63rd

n. Integral Communications Port

o. Mounting: Display and control unit flush or semiflush, mounted in instrument compartment door.

4. Data Communications:

a. Means to transmit data to central control and monitoring system.

b. Digital communication port connection in MODBUS TCP compatible communication protocol to communicate with Building Automation System (BAS) via Ethernet.

c. Keypad and scrollable display for local reading of measured values.

C. Distribution Panel and Branch Circuit Panelboard Kilowatt-Hour Meters:

1. Manufacturers:

a. E-MON L.P

b. National Meter Industries, Inc.

c. Osaki Meter Sales, Inc.

d. Power Measurement

e. Square D

f. Cutler-Hammer

g. General Electric

h. Siemens

i. Approved equal

2. Kilowatt-Hour/Demand Meter: Electronic three-phase meters, measuring electricity use and demand.

a. Voltage and Phase Configuration: Designed for use on circuits with voltage rating and phase configuration indicated for its application.

b. Demand Signal Communication Interface: Match signal to building automation system input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.

c. Programmable Contact Module: Unit shall have push-button switches and a display for setting the demand level at which an integral set of Form C contacts shall be operated to initiate indicated action.

d. Enclosure: NEMA 250, Type 1 minimum, with hasp for padlocking or sealing.

e. Identification: Comply with Section 26 0553 – Electrical Systems Identification.

f. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.

g. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for ratings of circuits indicated for this application.

1) Type: Split and solid core.

a). Meter Accuracy: Nationally recognized testing laboratory certified to comply with ANSI C12.1.

b). Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.

PART 3 - EXECUTION

3.1. COORDINATION

A. Coordinate adjustment and programming of metering equipment with manufacturer.

B. Coordinate with miscellaneous trades for equipment foreign to electrical installation to be outside of dedicated electrical space.

C. Verify with manufacturer that “touch-up” paint kit is available for repainting.

3.2. INSTALLATION

B. Comply with installation requirements in NECA 1.

C. Install engraved plastic nameplates under provisions of Section 26 0553 - Electrical Systems Identification for meter

D. Tighten electrical connectors and terminal according to equipment manufacturer’s published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A-486B.

E. Install fuses in fusible switch at job site per requirements in Section 26 2813 – Fuses.

F. Mount unit meters adjacent to metered equipment. Mounting height 5’-6” or less from finished floor.

3.3. FIELD WIRING

A. Install field wiring to complete the electricity metering installation.

1. Transformer-rated meter:

a. Current transformer wiring shall be 4 mm2(#12 AWG) minimum size. Where distance to meter exceeds 6.7 m(22 ft), increase wire size to 6 mm2(#10 AWG) to reduce the burden on the metering circuit.

b. Potential wiring shall be 2.5 mm2(#14 AWG).

c. Color coding: Same for current and potential wiring. A phase – black; B phase – red; C phase – blue; Neutral – white; Ground – green. Identify all wiring with plastic sleeve wire markers. Cloth markers are not acceptable.

d. Neatly train and lace wiring for metering installation within pad-mounted transformer compartment and meter socket enclosure using nylon cable ties.

3.4. CONNECTIONS

A. Ground metering equipment according to Section 26 0526 – Grounding and Bonding for Electrical Systems.

B. Connect power and control wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

C. Bond meter socket enclosure to grounding facilities. Grounding equipment per UL 467 requirements.

3.5. FIELD QUALITY CONTROL

A. Test continuity of each circuit.

B. Test metering equipment per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

C. Interpret test results in writing and submit to Engineer.

D. Test metering installation for proper operation, accuracy, and usability of output data.

1. Connect a load of known kilowatt rating, 1.5kW minimum, to a circuit supplied by metered feeder.
2. Turn off circuits supplied by metered feeder and secure them in off condition.
3. Run test load continuously for 8 h, minimum, or longer to obtain a measurable meter indication. Use test load placement and setting that ensures continuous, safe operation.

4. Check and record meter reading at end of test period and compare with actual electricity used based on test load rating, duration of test, and sample measurements of supply voltage at test load connection. Record test results.
5. Repair or replace deficient or malfunctioning metering equipment, or correct test setup; then retest. Repeat for each meter in installation until proper operation of entire system is verified.

E. Verify that correct multiplier is indicated on face of meter.

F. Verify that current transformer secondary circuits are intact.

G. Inspect indicating devices for proper operation.

3.6. REPAINTING

A. Remove paint splatters and other marks from surface of equipment.

B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Owner.

3.7. ADJUSTING

A. Adjustment and programming of metering equipment: By factory-authorized representative.

B. Compare meter display readings with readings taken with clamp on ammeter and hand held volt-meter.

C. Make adjustments as necessary.

3.8. CLEANING

A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

3.9. DEMONSTRATION

A. Provide training session by manufacturer for up to 4 h at a job location, to train the Owner’s personnel in the operation and maintenance of metering equipment.

End of Section

SECTION 26 09 23

LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 00 00 - General Electrical Requirements

B. Section 26 51 00 - Lighting Fixtures

1.2 REFERENCE

A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 DESCRIPTION OF SYSTEM

A. Provide devices such as wall box dimmers, wall and ceiling mounted occupancy sensors, ambient light sensors, sensor power packs, etc., as shown on drawings.

B. Openings shall be covered with devices and matching plates.

C. Devices of same type shall be from same manufacturer.

1.4 REFERENCE STANDARDS

A. UL20 - General Use Snap Switches.

B. UL773A - Non-Industrial Photoelectric Switches for Lighting Control.

C. NEMA WD 7 - Occupancy Motion Sensors.

1.5 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section.

B. Device color samples.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers:

1. Wall Box Dimmers: Hubbell, Levitan, Lutron, Lightolier (Sunrise and Momentum Series), Prescolite, Unenco
2. Ceiling Sensors:
   a. Ultrasonic Occupancy Sensors: Hubbell, Unenco, Light-O-Matic, MyTech, Novitas Wattstopper (W Series)

b. Ultrasonic Occupancy Sensors, Switched: MyTech

c. Passive Infrared Occupancy Sensors: Hubbell, Lightolier (Insight Series), MyTech, Tork, Unenco, Wattstopper

d. Dual Technology Occupancy Sensors, PIR and Ultrasonic: Hubbell, MyTech, Unenco, Wattstopper (DT Series)

e. Ambient Light Sensors: Hubbell, MyTech, Leviton, Lightolier (Insight Series), Uneco, Wattstopper

3. Wall Sensors:

a. Passive Infrared Occupancy Sensors: Leviton, Lightolier (Insight), MyTech, Unenco, Wattstopper

b. Passive Infrared Switched Occupancy Sensors: Hubbell, Lightolier, MyTech, Unenco, Wattstopper

c. Passive Infrared Occupancy Sensors, Dual Level, Switched: MyTech

d. Dual Technical Occupancy Sensors, PIR and Ultrasonic, Switched: MyTech

e. Passive Infrared Occupancy Sensors with Ambient Light Sensor: Leviton, Unenco, Wattstopper

4. Power Packs: Light-O-Matic, Lightolier, Leviton, MyTech, Novitas, Tork, Unenco, Wattstopper

5. Photocells: Intermatic, Paragon, Tork

6. Timeclocks: Intermatic, Paragon, Tork

B. It is the responsibility of Electrical Contractor to ensure devices submitted meet or exceed functional intent and design quality standards.

2.2 FABRICATION AND MANUFACTURE

A. Devices shall be UL listed for loads and voltages as shown on drawings.

2.3 WALL BOX DIMMERS

A. Dimmers shall:

1. Be ivory colored.
2. Operate in ambient temperature range of 0°C (32°F) to 40°C (104°F).
3. Be linear slide preset dimmers with power-failure memory.
4. Incorporate separate control of intensity and on/off.
5. Include voltage compensation circuitry that adjusts firing angle of dimmer to compensate light output for variations in AC line voltage. Dimmers in which firing angle is held constant with varying AC line voltage shall not be acceptable.
6. Provide smooth and continuous IESNA Square Law Dimming Curve throughout entire dimming range.
7. Incorporate filter network to minimize interference (RFI) with radio, audio, and video equipment.
8. Incorporate air-gap switch to meet requirements of UL 20 for air-gap switches in incandescent dimmers.

B. Fluorescent dimmers shall be:

1. Rated to control 430 mA rapid start, 800 mA high output or 265 mA lamps.
2. Be approved by ballast manufacturer for control of ballasts provided.
3. Contain relay to automatically remove power to circuit feeding dimming ballast when dimmer is off.
4. Incorporate circuitry to prevent lights from momentarily "flashing" when dimmer is turned on or off.
5. Different lamp lengths or one and two lamp ballasts on same circuit shall track evenly with no perceptible difference in light levels for same type of lamps.
6. Dimmers and lamps shall have a dimming range from 100% down to 20% light output.
7. Refer to Section 26 5100 - Lighting Fixtures for solid state dimming ballast specification.

2.4 OCCUPANCY SENSORS

A. Occupancy Sensor shall:
   1. Be Match other devices in area colored.
   2. Operate with all lamp and ballast combinations, including magnetic, hybrid, and solid-state ballasts.
   3. Have LED to indicate occupant detection.
   4. Have adjustable time delays from 30 seconds to 15 minutes and adjustable sensitivity.

B. Ultrasonic circuit shall be:
   1. Solid-state crystal controlled.
   2. 32 kHz minimum.

C. Ceiling ultrasonic occupancy sensors shall:
   1. Have 360° coverage with ceiling height of 12 ft.
   2. Be low voltage wired in parallel to common power pack.
   3. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.
   4. Contain isolated relay with normally open, normally closed, and common outputs for use with EMCS system, data logging, or other system control options.

D. Passive infrared occupancy sensors shall:
   1. Incorporate temperature compensated dual element sensor and multi element fresnel lens.
   2. Have daylight filter to ensure sensor is insensitive to short-wave length waves emitted by sun.
   3. Contain isolated relay with normally open, normally closed, and common outputs for use with EMCS system, data logging, or other system control options.

E. Ceiling passive infrared occupancy sensors shall:
   1. Have round, square, or long rectangular coverage patterns to match floor plan layout.
   2. Operate within ceiling height of 12 ft.
   3. Be low voltage wired in parallel to common power pack.
   4. Contain isolated relay with normally open, normally closed, and common outputs for use with EMCS system, data logging, or other system control options.

F. Wall passive infrared occupancy sensors shall:
   1. Incorporate all features and performance of passive infrared sensors except for switching.
   2. Have switch for either off or auto for normal operation.
   3. Be completely self contained to replace standard toggle switches.
      a. Switching mechanism shall be latching air gap relay.
      b. Units may be low voltage devices with sensor power packs similar to ceiling mounted devices.
      c. Power supply shall be internal transformer.
   4. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.
   5. Have 170° radial spread pattern with minimum of 20 ft axial sensor coverage.
   6. Be user adjustable for normal operation.
      a. Sensor shall operate similar to toggle switch, tap on and tap off, with sensor maintaining lighting during detection and time delay lights off.
      b. Alternate operation shall be sensor detection lights on, with sensor maintaining lighting during detection and time delay off.

7. Contain isolated relay with normally open, normally closed, and common outputs for use with EMCS system, data logging, or other system control options.
8. With ambient light sensor shall incorporate all features and performance of passive infrared sensors and ambient light sensors.
   a. Ambient light sensor shall be internal with range of 5 to 300 footcandles.
   b. Ambient light sensing component shall not permit lighting systems to be turned on if enough daylight is present.

G. Dual technology occupancy sensors shall:
1. Include both ultrasonic and passive infrared sensors. Each sensing technology shall have independent sensitivity adjustments and LED to indicate detection.
2. Built-in light level sensor: 10 to 300 footcandles
3. Be designed to be either wall or ceiling mounted as indicated on drawings.
4. Sense motion from both technologies to turn lighting on, but maintained detection from either technology will hold lighting on for set time delay.
5. Be low voltage wired to sensor power packs.
6. Contain isolated relay with normally open, normally closed, and common outputs for use with EMCS system, data logging, or other system control options.

H. Ambient light sensors shall:
1. Incorporate photoconductive cell to measure light levels between 10 and 1,000 footcandles.
2. Be adjustable with deadband feature to prevent cycling of lighting from minor changes in cloud cover.
3. Have adjustable time delay range from 15 seconds to 5 minutes.
4. Not permit lighting systems to be turned on if enough daylight is present.
5. Incorporate by-pass switch to enable lighting to be turned on if sensor fails.
6. Be low voltage wired in parallel to power packs.

I. Sensor power packs shall:
1. Be self-contained transformer relay modules.
2. Have dry contacts capable of switching 20 amp load at either 120VAC or 277VAC.
3. Provide 24VDC output capable of controlling ultrasonic or passive infrared occupancy sensors.

2.5 PHOTOCELLS

A. Photocells shall:
1. Be rated 2,000 watts tungsten at 120, 240, or 277 volts.
2. Have cadmium sulfide, 1" diameter cell.
3. Have SPST normally closed contacts.
4. Have delay of up to 2 minutes to prevent false switching.
5. Have 5-year warranty.

B. ON/OFF adjustment shall be done by moving light selector with range from 2 to 50 footcandles.

C. Operational temperature range shall be -40 to 140°F (-40 to +60°C).

D. Enclosure shall be die cast zinc, gasketed for maximum weatherproofing.

E. Enclosure shall include positioning lug on top.

F. Mounting shall be for 1/2" conduit nipple.

2.6 TIMECLOCKS

A. Timeclocks shall:
   1. Be multi-purpose, 7-day, 365-day advance single and skip a day, combination 4-channel electronic time clock with (4) SPDT switching configuration and astronomic dial.
   2. Be rated for 30 VDC, 120 VAC, 250 VAC and 277 VAC.
   3. Be capable of programming in AM/PM or 24-hour format by jumper selection, in one-minute resolution, using 2 buttons for basic settings.
   4. Have 365-day and/or holiday selection capabilities, with 16 single date and 5 holiday selection options and user selectable daylight savings/standard time functions.
   5. Have 72-hour memory backup with rechargeable battery and charger.
   6. Be capable of manual override, ON and OFF to the next scheduled event, using one button for each channel.
   7. Have operational temperature range of -40 to 150°F.

B. Contacts shall be rated 10 amp resistive at 120/250 VAC, 7.5 amps inductive at 120/250 VAC, 5 amps inductive at 30 VDC and up to 1/2 hp at 250 VAC.

C. Display shall be LED type.

D. Flush mounted enclosure shall be NEMA 1 rated for indoor installation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install devices at heights scheduled, and as indicated on drawings.

B. Install wall devices vertically on latch side of door within 6" of frame edge, unless otherwise noted.

C. Install ceiling devices as shown on drawings and as recommended by device manufacturer.

D. Ceiling mounted occupancy sensors shall be located minimum of 6 ft from supply air diffusers.

E. Install devices plumb, level with finished surfaces and free from blemishes.

F. Verify device locations prior to rough in.

G. Control wiring shall be low voltage, Class II wiring, electrically isolated from power wiring by a Class II transformer.

H. Provide separate neutral conductor for each dimmer.

I. Wiring shall be in conduit.

J. Electrical Contractor shall be responsible for final adjustment and testing of all devices.

3.2 TESTING

A. Check dimmer preset control for proper operation.

B. Verify dimmers function without producing lamp flicker or audible noise.

C. Verify dimmers function without interference of audio and visual equipment.

D. Adjust room occupancy sensor(s) for a 5 minute time delay.

E. Adjust corridor and passage occupancy sensor(s) to maximum time delay setting

F. Verify proper operation of occupancy sensor switches and by-pass switches.

G. Adjust occupancy sensor sensitivity such that movement outside range of coverage shall not trigger sensor.

3.3 STARTUP

A. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

SECTION 26 12 16

CAST COIL TRANSFORMERS (ABOVE 600 VOLTS)

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 00 00 - General Electrical Requirements

B. Section 26 05 53 - Electrical Identification

C. Section 26 08 12 - Power Distribution Acceptance Tests

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. This Specification covers dry type transformers, with primary voltage above 600 volts, for pad mounted use. For use outdoors.

1.4 REFERENCE STANDARDS

A. ANSI C57.12.50 - Requirements for Dry-Type Distribution Transformers, 1-500 kVA single-phase and 15-500 kVA three-phase, with high voltage 601 - 34,500 volts, low voltage 120-1000 volts.

B. ANSI C57.12.51 - Dry-Type Power Transformers 501 kVA and Larger, Three-Phase with High-Voltage 601 to 34 500 Volts, Low-Voltage 208Y/120 to 4160 Volts, Requirements for Ventilated.

C. ANSI C57.12.55 - Dry-Type Transformers in Unit Installations, Including Unit Substations - Conformance Standard.

D. ANSI C57.12.70 - Terminal Markings and Connections for Distribution and Power Transformers.

E. IEEE C57.12.01 - General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin Encapsulated Windings.

F. NEMA 5T20 - Dry Type Transformers for General Applications.

G. UL 1561 - Dry Type General Purpose and Power Transformers.

1.5 SUBMITTALS

A. Submit Shop Drawings for equipment provided under this Section.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers: Square D

2.2 RATINGS

A. Ratings of transformer shall be as follows:

kVA Rating		as shown on drawings
Primary Voltage	13.2	kV Wye
Primary BIL	60	kV
Secondary Voltage	480	Volts Wye
Secondary BIL	30	kV
Impedance	5.75	%
Taps	4	Nominal 2.5% taps, 2 above and 2 below primary voltage

2.3 CONSTRUCTION

A. Transformer shall be cooled by natural air convection (AA).
   1. Temperature sensing in all three coils.

2.4 CORE AND COIL

A. Coil
   1. Windings shall be copper. Other materials are not acceptable.

B. Core
   1. Constructed of high grade, grain oriented, non-aging silicon steel.

2.5 INSULATION TYPE CAST COIL

A. Electrical Insulation
   1. Insulation system shall be rated 185°C.
   2. Solid insulation shall consist of inorganic materials such as glass fiber, electrical grade epoxy and Nomex.
   3. Epoxy cast coil design.
   4. Insulation between layers of the windings shall be Insuldur Paper or equal.

B. Temperature Rise
   1. Average temperature rise of transformer windings shall not exceed 150°C.
   2. Temperature rise based on 40°C maximum ambient.

2.6 TAPS

A. Taps shall be:
   1. Rigidly supported
   2. Marked for connections
   3. Accessible from front or back by panel removal.

2.7 ENCLOSURES

A. Transformer Enclosure shall be:
   1. Constructed of 12-gauge sheet steel.

2. Equipped with removable panels for access to core and coils.
3. Front and rear panels with ventilated grills.
4. Rubber isolation pads to isolate core from case. There shall be no metal-to-metal contact.
5. Hinged doors.

B. Outdoor transformers shall include:
1. Thermostatically controlled space heaters
2. External power source which remains energized when transformer is de-energized.
3. Ventilating grills that restrict passage of rain or spray.
4. Forced air cooling to increase the continuous self cooled rating of the transformer by 33 1/3%. The FA increase shall be possible with forced cooling without exceeding the specified maximum temperature rise. The forced air cooling shall be regulated automatically by sensors placed in the low voltage winding's air ducts. Forced air cooling shall include: three phase electronic digital temperature monitor, fans, control wiring, control panel with test switch, indicating lights, alarm and alarm silencing switch.

C. Finish
1. Transformer enclosure and rails shall be finished with manufacturers standard finish.
2. Outdoor transformers shall have outdoor paint finish.

2.8 NAMEPLATE

A. Nameplates shall be:
1. Secured to transformer enclosure with screws.

B. Transformer:
1. Transformer shall have nameplate with:
a. Manufacturer's name and drawing number.
b. Transformer identification tag as indicated on drawings
c. Electrical connection diagram
d. Primary and secondary voltage rating
e. kVA rating
f. Basic Impulse Level

C. Doors:
1. External hinged doors and hinged bolted panels shall be provided with "Caution - High Voltage - Keep Out" signs.

D. Submit identification to ANL/Architect/Engineer for approval.

2.9 ACCESSORIES

A. Transformer shall include:
1. Provisions for lifting and jacking.
2. Removable panel for access for de-energized tap changing.
3. Two ground pads.

2.10 TERMINAL COMPARTMENTS

A. Transformer shall include HV terminal compartment and terminal compartment with busway flange.

B. Connections between:

1. Primary device and transformer shall be cable.
2. Transformer and secondary shall be Bus.

C. Secondary neutral connection shall be brought out for bonding to ground bar.

D. Provide removable link between neutral point and ground bar.

PART 3 - EXECUTION

3.1 INSPECTION

A. Visually inspect all equipment and components at time of delivery. Submit report to ANL/Architect/Engineer with list of items to be corrected.

3.2 INSTALLATION

A. Install equipment per manufacturer's recommendations and as indicated.

B. Coordinate final locations of equipment with Contractor, and review final locations with Architect/Engineer prior to setting equipment.

C. Install transformer on concrete base.

D. Anchor transformer to concrete bases in accordance with manufacturer’s written instructions, and requirements in Section 16070 - Seismic Anchorage and Restraint.

E. Transformer must be installed level and plumb.

3.3 FACTORY TESTING

A. The following standard factory tests shall be performed on equipment provided.
1. Resistance measurements of all windings and at the tap extremes of one unit only of a given rating on this Project.
2. Ratio tests on the rated voltage connection and on all tap connections.
3. Polarity and phase-rotation tests.
4. No-load loss at rated voltage.
5. Excitation current at rated voltage.
6. Impedance and load loss at rated current and on the tap extremes of one unit only of a given rating on this Project.
7. Applied potential tests.
8. Induced potential tests.
9. Sound Test.
10. Manufacturer shall provide 3 certified copies of factory test reports.

B. The following special factory tests shall be performed on equipment provided.
1. Tests shall not be required when there is available a record of a temperature test on a duplicate unit.
2. Basic impulse test on all windings.

C. Factory tests above shall be witnessed by the ANL's representative.
1. Manufacturer shall notify ANL 2 weeks prior to date tests are to be performed.
2. Manufacturer shall include cost of transportation and lodging for up to 3 ANL's representatives.
3. Cost of meals and incidental expenses shall be ANL's responsibility.

3.4 ACCEPTANCE TESTING

A. Testing by Testing Agency

B. Acceptance testing to be performed in accordance with Section 26 0812 - Power Distribution Acceptance Tests.

C. Equipment shall have passed applicable acceptance tests before energization.

D. Manufacturer’s Field Service:
   1. Engage factory-authorized service representative to inspect, and adjust field assembled components and equipment installation, including connections.
   2. Measure primary and secondary voltages and make appropriate tap adjustments.
   3. Contractor shall provide 3 copies of manufacturer's representative's certification.

3.5 CLEANING OF TRANSFORMER

A. Transformer shall be cleaned prior to initial testing and energization of unit, and again prior to final punch list.

B. Cleaning procedures shall be as follows:
   1. Vacuum all surfaces of enclosure and transformer.
   2. Blow out all components with dry compressed air.
   3. Use small paintbrush to dust small, hard to reach crevices.

End of Section

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SECTION 26 22 00

LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems

C. Section 26 05 29 – Hangers and Supports for Electrical Systems

D. Section 25 05 33 – Raceway and Boxes for Electrical Systems

E. Section 26 05 53 – Electrical Systems Identification

F. Section 26 08 12 – Power Distribution Acceptance Tests

G. Section 26 08 13 – Power Distribution Acceptance Test Tables

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes dry type distribution and buck-boost transformers rated 600V and less, with capacities up to 300 kVA.

1.4 REFERENCE STANDARDS

A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting

B. IEE C57.12.91 – Test Code for Dry Type Distribution and Power Transformers

C. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)

D. NEMA ST 1 – Specialty Transformers (except General Purpose Type)

E. NEMA ST 20 – Dry-Type Transformers for General Applications

F. NEMA TP 1 – Guide for Determining Energy Efficiency for Distribution Transformers

G. NEMA TP 2 – Test Method for Measuring the Energy Consumption of Distribution Transformers

H. NEMA TP 3 – Standard for the Labeling of Distribution Transformer Efficiency

I. NFPA 70 – National Electrical Code

J. UL 506 – Specialty Transformers

K. UL 1561 – Dry-Type General Purpose and Power Transformers

1.5 SUBMITTALS

A. Product Data:
   1. Include rated nameplate data, capacities, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings:
   1. For each transformer size and type:
      a. Physical dimensions, including bolting templates, weight, and center of gravity
      b. Loads, method of field assembly, components, and location and size of each field connection
      c. Wiring Diagrams: Power, signal, and control wiring
      d. kVA rating
      e. Primary taps
      f. Insulation class and temperature rise
      g. Efficiency values measured at 0, 25, 50, 75, and 100% load
      h. Impedance value – X/R and %Z
      i. Sound level
      j. “K” factor listing, where applicable

C. Submit 1/4" scale electrical room floor plans with transformer locations.

D. Manufacturer’s Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

E. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

F. Output Settings Report: Record output voltages and tap settings.

G. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations of transformers.
   2. Operation and Maintenance Data:
      a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include spare parts data listing, source, and current prices of replacement parts and supplies.
      c. Include in emergency, operation and maintenance manuals.
      d. Include manufacturer’s Seismic Qualification Certification, Installation Seismic Qualification Certification, manufacturer’s Ultra Quiet Transformers Sound Level Certification, where applicable, and Output Settings Report.

1.6 QUALITY ASSURANCE

A. Obtain transformers from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.

B. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D

B. General Electric

C. Cutler-Hammer

D. Siemens

2.2 DISTRIBUTION TRANSFORMERS

A. Fabrication:
   1. NEMA ST 20, UL 1561
   2. Factory assembled and tested
   3. Air-cooled, for 60 Hz service
   4. Two winding dry type
   5. Coils:
      a. Continuous wound construction and impregnated with non-hydroscopic, thermosetting varnish.
      b. Conductors: Continuous windings without splices, except for taps, and encapsulated wire resin compound to seal out moisture and air.
      c. Materials: [Aluminum] [Copper]
      d. Separate primary and secondary
      e. Internal Connections: Braised or pressure type

6. Cores: High-grade silicon steel, non-aging, with high magnetic permeability, low eddy current losses and low hysteresis. Magnetic flux densities below saturation point. Core laminations clamped with steel members, one leg per phase.
7. Rubber vibration absorbing mounts to isolate base of enclosure from core and coil assembly.
8. Transformer neutral visibly grounded to enclosures with flexible grounding conductor.

B. Enclosure:
1. NEMA 250
2. Type 2, unless otherwise indicated to comply with environmental conditions at installed location.
3. Code-gauge steel panel over core and coil.
4. Ventilated (air-cooled): Louvered openings for convection cooling.
5. Cooling and terminal chamber access with both sides and rear obstructed.
6. Manufacturer's lifting eyes or brackets.
7. Finish: Manufacturer's standard gray enamel over prime coat after being degreased, cleaned, and phosphatized.

C. Ratings:
1. KVA Rating: 300 kVA maximum
2. Primary Voltage: 480V, 3-phase, 3 wires
3. Secondary Voltage: 208Y/120V, 3-phase, 4 wires
4. Insulation Class and Winding Temperature Rise:
   a. Transformers 15kVA and smaller: Class 365°F, with 239°F temperature rise above 104°F ambient temperature, capable of carrying 15% continuous overload without exceeding 302°F rise.
   b. Transformers 25kVA – 112.5kVA: Class 428°F, with 239°F temperature rise above 104°F ambient temperature, capable of carrying 15% continuous overload without exceeding 302°F rise.
   c. Transformers above 112.5kVA: Class 428°F, with 176°F temperature rise above 40°C ambient temperature, capable of carrying 30% continuous overload without exceeding 302°F.
5. Top of Enclosure Temperature: Maximum 95°F above 104°F ambient temperature at warmest point at full load.
6. K-Factor Rating: UL 1561, as indicated.

D. Primary Taps:
1. Transformers rated 15kVA and larger: Two 2.5% above and two 2.5% below normal full capacity, minimum of four taps.

E. Energy Efficiency:
1. Transformers rated 15kVA and larger, except K-rated, quiet type and ultra quiet type:
   a. NEMA TP 1, Class 1 efficiency level.
   b. Manufacturer's test to NEMA TP2.
   c. NEMA TP 3 Energy Star label.

F. Sound Levels:
1. NEMA ST 20, maximum average sound levels as follows:
   a. 45 dB for general-purpose transformer sizes less than 51kVA.
   b. 50 dB for general-purpose transformer sizes 51-150kVA.
   c. 55 dB for general-purpose transformer sizes 151-300kVA.

G. Electrostatic Shielding, where indicated: Each winding with an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
   1. Coil leads and terminal strips arranged to minimize capacitive coupling between input and output terminals.
   2. Special terminal included for grounding the shield.
   3. Shield Effectiveness:
      a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
      b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
      c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

2.3 BUCK-BOOST TRANSFORMERS

A. Description: NEMA ST 1, UL 506, UL 1561, same as distribution transformers, except rated for continuous duty and with wiring terminals suitable for connection as autotransformer.

B. Enclosure: Ventilated, NEMA 250, Type 2.
   1. Finish Color: ANSI 49 gray or ANSI 61 gray.

2.4 LUGS

A. Manufacturer's primary and secondary bolted lugs: labeled for 167°F copper and aluminum conductors for ventilated enclosures [and labeled for 194°F copper and aluminum conductors for non-ventilated enclosures].

B. Connections at sides near bottom, accessible from front of cabinet.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure and ambient temperature requirements for each transformer.

B. Examine areas and surface to receive transformers for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Verify space indicated for transformers' mounting meets code-required working clearances.

D. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

E. Verify that ground connections are in place and requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems have been met.

F. Verify with manufacturer that "touch-up" paint kit is available for repainting.

3.2 INSTALLATION

A. Install transformers in accordance with ANSI/NECA 1.

B. Install level and plumb within 1/2 degree, and at least 6” from the adjacent wall or structure to insure proper ventilation, in accordance with manufacturer’s written instruction, and in compliance with recognized industry practices.

C. Transformer mounting, seismic restraints, and vibration control:
   1. Install transformer anchorage devices based on design by an Engineer registered and licensed in the State.
   2. Mount transformers on floor.
   3. Floor mounting:
      a. Secure to floor via isolation pads between floor brackets (fabricated by manufacturer) and transformer.
      b. Mount on spring isolator.

D. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to transformer using small, corrosion-resistant metal screws or rivets. Do not use contact adhesive.
   1. Indicate kVA rating, voltage/phase rating, taps, insulation class and temperature rise, impedance value, sound level, and K-factor listing.

E. Connect each transformer to rigid conduit system with maximum 36” of flexible liquid-tight metal conduit. Install conduit per requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.

F. Install transformer in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.

3.3 CONNECTIONS

A. Ground transformers according to Section 26 0526 – Grounding and Bonding for Electrical Systems.

B. Connect wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

3.4 FIELD QUALITY CONTROL

A. Inspect transformers for physical damage, proper alignment, anchorage, grounding, connections, and installation.

B. Test transformers per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

C. Interpret test results in writing and submit to Engineer.

D. Output Settings Report: Prepare a written report recording output voltages and tap settings and submit to Engineer.

3.5 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.

B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with ANL.

3.6 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10% and not being lower than nameplate voltage minus 3% at maximum load conditions.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5%, at secondary terminals.

3.7 CLEANING

A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

End of Section

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SECTION 26 23 00

LOW-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 23 09 01 – Control Systems Integration

B. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

C. Section 26 05 26 – Grounding and Bonding for Electrical Systems

D. Section 26 05 29 – Hangers and Supports for Electrical Systems

E. Section 26 05 53 – Electrical Systems Identification

F. Section 26 05 73 – Overcurrent Protective Device Coordination Study

G. Section 26 08 12 – Power Distribution Acceptance Tests

H. Section 26 08 13 – Power Distribution Acceptance Test Tables

I. Section 26 09 13 – Electrical Power Metering

J. Section 26 28 13 – Fuses

K. Section 26 43 00 – Transient Voltage Suppression

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 DESCRIPTION

A. Section includes free-standing, dead-front type, metal-enclosed, low-voltage distribution switchgear.

1.4 REFERENCE STANDARDS

A. ANSI/IEEE C37.13 – Low-Voltage AC Power Circuit Breakers Used in Enclosures

B. IEEE C37.20.1 – Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

C. IEEE C37.90 – Relay and Relay Systems Associated with Electric Power Apparatus

D. IEEE C62.11 – Metal-Oxide Surge Arresters for Alternating Current Power Circuits

E. IEEE C62.41 – Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits

F. NFPA 70 – National Electrical Code

G. NEMA LA 1 – Surge Arresters

H. NEMA 2250 – Enclosures for Electrical Equipment (1000 Volts Maximum)

I. UL 486A-486B – Wire Connectors

J. UL 869A – Reference Standard for Service Equipment

K. UL 1066 – Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures

L. UL 1558 – Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

1.5 SUBMITTALS

A. Product Data: For switchgear, components and accessories indicated:
   1. Include data on features and components and complete description; submit catalog cut sheets showing voltage, size, rating and size of transient voltage suppression device, switching and overcurrent protective devices.
   2. Features, characteristics, factory settings and time-current curves of individual protective devices, auxiliary components and ground fault relaying.

B. Shop Drawings:
   1. For switchgear specified in this Section:
      a. General Arrangement:
         1) Indicate front, plan, and side views of switchgear; access requirements; overall dimensions and components list; shipping splits and weights.
         2) Front elevation indicating location of devices and instruments.
         3) Sections through switchgear showing space available for conduits.
      b. Conduit entrance locations and requirements
      c. Nameplate legends
      d. Configuration, size and number of bus bars for each phase and current rating of buses
      e. Ground bus
      f. Neutral bus
      g. Short circuit ratings of switchgear and overcurrent protective devices, and bus withstand rating
      h. Instrument details; enclosure types and details
      i. Wiring diagrams: power, signal and control wiring
   2. Submit 1/4" scale floor plans with switchgear location and required clearances and service space around equipment.

C. Manufacturer’s Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

D. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

E. Complete review of this specification noting for each paragraph whether proposed equipment complies with project specifications or deviates. Justification must be given for each deviation.

F. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations, configurations, and ratings of switchgear and major components on single-line diagrams and plan layouts.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include manufacturer's written instructions for testing and adjusting overcurrent protective devices.
      c. Include spare parts data listing, source, and current prices of replacement parts and supplies.
      d. Include time-current curves, including selectable ranges for each type of overcurrent protective device.

1.6 QUALITY ASSURANCE

A. Obtain switchgear from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters in switchgear as required to prevent condensation.

B. Deliver switchgear in (48") maximum width shipping splits, individually wrapped for protection, and mounted on shipping skids. Mark crates, boxes, and cartons clearly to identify equipment. Show crate, box, or carton identification number on shipping invoices.

C. Use factory-installed lifting provisions. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.9 MAINTENANCE

A. Extra Materials: Furnish extra materials described below that match product installed, are packaged with protective covering for storage, and are identified with labels describing contents.
   1. Potential Transformer Fuses: Equal to 10% of amount installed for each size and type, but no fewer than 2 of each size and type.

2. Control-Power Fuses: Equal to 10% of amount installed for each size and type, but no fewer than 2 of each size and type.
3. Fuses for Fused Switches and for Fused Circuit Breakers: Equal to 10% of amount installed for each size and type, but no fewer than 3 of each size and type.
4. Indicating Lights: Furnish 6 of each type required. Equal to 10% of amount installed for each size and type, but no fewer than 2 of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D

B. General Electric

C. Cutler-Hammer

D. Siemens

2.2 RATINGS

A. Nominal system voltage: As indicated on the drawings or scheduled.

B. Main bus continuous amperes: As indicated on the drawings or scheduled.

C. Short circuit current rating: as indicated on drawings.

D. Brace switchgear components to withstand mechanical forces for symmetrical fault current shown.

2.3 CONSTRUCTION

A. IEEE C37.20.1, UL 1558.

B. Free-standing, dead-front type; metal-enclosed; side, front and rear panels of one-piece welded or bolted construction; compartments with ventilation louvers in top and bottom sections of front and rear panels; supporting frame: steel channels rigidly fastened together, with same outside dimensions as the enclosure.

C. Adequate strength and rigidity necessary to resist conditions of use to which it may be subjected and to support equipment, devices and appurtenances contained therein.

D. Incoming lug locations: Top or bottom, as applicable per drawings.

E. Connection to the supply source by conduit and wiring.

F. Environmental Limitations:
1. Ambient temperatures: not exceeding 104°F
2. Altitude: Not exceeding 6600 ft
3. Temperature rise: Not to exceed 149°F over a 104°F ambient environment, with no de-rating required.

G. Device Mounting and Type:
1. Front and rear accessible switchgear: Front and rear aligned
   a. Main and tie device and feeder devices: Drawout and compartmented power circuit breakers.

H. Bus:

1. Material: Copper: 98% conductivity.
2. Connections: Accessible from rear only for maintenance.
   a. Bolted:
      1) Grade 5 bolts and conical spring-type washers
3. Sizing: Standard size, based on 149°F over 104°F; full capacity of the breaker frame size, not the trip setting; fully rated vertical and horizontal bus sections.
4. Main Phase Buses: Three phase, 4 wire; uniform capacity for entire length of switchgear; ampacity as indicated on drawings; rated for the main protective device frame size or main incoming conductors.
5. Bus Arrangement: A-B-C (left to right, top to bottom, front to rear).

I. Ground Bus: Insulated, extend length of switchgear.

J. Neutral Bus: 50 % of the ampacity of phase buses, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.

K. Hinged Front Doors: Allow access to metering, accessory, and blank compartments, with latch and padlocking provisions.

L. Removable, Hinged Rear Doors and Compartment Covers: Secured for access to rear interior of switchgear, with latch and padlocking provisions.

M. Circuit breaker compartment: Equipped to house drawout type circuit breakers, fitted with hinged outer doors, and segregated from adjacent compartments by steel barriers; equipped with drawout rails, levering out mechanism, primary and secondary contacts; The following functions may be performed without the need to open the circuit breaker door: lever circuit breaker between positions, operate manual charging system, close and open circuit breaker, examine and adjust trip unit, and read circuit breaker rating nameplate.

N. Section barriers between main and tie circuit breakers compartments: Extended to rear of section; rear compartment barrier between the cable compartment and the main bus; glass polyester barrier between adjacent vertical structures in the cable compartment.

O. Bus isolation barriers: Arranged to isolate line bus from load bus at each main and tie circuit breaker; separate barriered compartment for current and potential transformers; main and riser buses fully isolated from breaker instrument and auxiliary compartments.

P. Bus bars connect: Between vertical sections and between compartments. Cable connections are not permitted.

Q. Safety shutter: To automatically cover line and load stubs to protect against accidental contact.

R. Incoming Pull Sections: Matched and aligned with basic switchgear.

S. Spare circuit breakers and spaces for future circuit breakers: Allowance in vertical section bus size.

T. Future Provisions: Fully equip spaces for future devices with bussing, bus connections, rails, mounting brackets, supports, and appurtenances, insulated and braced for short circuit currents, with continuous current rating as indicated on drawings. Extension of phase, neutral, and ground buses from both ends by means of predrilled bolt-holes and connecting links.

U. Adequate lifting means.

V. Dimensions: 90” maximum height, excluding floor sills, lifting members and pull boxes. Length and depth indicated on the drawing are maximums allowed.

W. Line and Load Terminations: Mechanical type, labeled for 75°C copper and aluminum conductors; suitable for number, sizes and trip ratings; feeder load terminals: silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.

X. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation, or fluidized epoxy coating. No live connections shall be accessible from the rear, except the breaker load side terminals.

Y. Sprayed Insulation Thickness: 3 mils, minimum.

Z. Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

AA. Relays: IEEE C37.90; types and settings as indicated; with test blocks and plugs.

BB. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchgear. Arrange in single-line diagram format showing bussing, connections and devices, using symbols and letter designations consistent with final mimic-bus diagram. Use black color factory painting. Coordinate mimic-bus segments with devices in switchgear sections to which they are applied. Produce a concise visual presentation of principal switchgear components and connections.

2.4 SERVICE ENTRANCE

A. UL 869A

B. Switchgear labeled as suitable for use as service entrance equipment, where applicable, with incoming line isolation barriers, and a removable neutral bond to switchgear ground for solidly grounded wye systems.

C. Surge arrestors on all phases: IEEE C62.11, NEMA LA 1; distribution class, metal-oxide-varistor type; per requirements in Section 26 4300 – Transient Voltage Suppression.

2.5 SHORT CIRCUIT CURRENT RATING

A. Switchgear with minimum short circuit current rating as indicated on drawings.

B. Switchgear: Marked with their maximum short circuit current rating at supply voltage.

C. Switchgear: Fully rated

2.6 TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS)

A. By switchgear manufacturer.

B. IEEE C62.41; integrally mounted, plug-in style, solid-state, parallel-connected, sine-wave tracking suppression and filtering modules.

C. Per requirements in Section 26 4300 – Transient Voltage Suppression.

2.7 OVERCURRENT PROTECTIVE DEVICES

A. Power Circuit Breaker and Accessories: ANSI/IEEE C37.13; UL 1066; metal frame; field interchangeable electrical accessories, including shunt trip, spring release, electrical operator, auxiliary contacts and trip unit.

1. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
2. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

a. Normal Closing Speed: Independent of both control and operator.
b. Slow Closing Speed: Optional with operator for inspection and adjustment.
c. Store-Energy
d. Means for manual opening and closing.
e. Operation counter.

3. Trip Devices: Electronic (solid-state, microprocessor-based), overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
   a. Functions: Long-time pickup and delay, short-time pickup and delay, ground-fault pickup and delay and instantaneous-trip functions, independent of each other in both action and adjustment.
   b. Temperature Compensation: Ensures accuracy and calibration stability from 23°F to 104°F.
   c. Field-adjustable time-current characteristics.
   d. Current Adjustability: Dial settings and ratings plugs on trip units or sensors on circuit breakers, or a combination of these methods.
   e. Three bands, minimum, for long-time- and short-time-delay functions; marked “minimum,” “intermediate,” and “maximum.”
   f. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I^2t operation.
   g. Pickup Points: Five minimum, for instantaneous-trip functions.
   h. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
4. Auxiliary Contacts: For interlocking or remote indication of circuit breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit breaker operation. Each consists of two type “a” and two type “b” contacts wired through secondary disconnect devices to a terminal block in stationary housing; “a” contacts mimic circuit breaker contacts, “b” contacts operate in reverse of circuit breaker contacts.
5. Drawout Features: Circuit breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:
   a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
   b. Circuit Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:
      1) Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
      2) Disconnected Position: Primary and secondary devices and ground contact disengaged.
6. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position and arranged to permit inspection of contacts without removing circuit breaker from switchgear.
7. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
8. Operating Handle: One for each circuit breaker capable of manual operation.
9. Electric Close Button: One for each electrically operated circuit breaker.
10. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.

11. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key interlock devices is indicated.
12. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage.
13. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.
14. Shunt-Trip Devices: Where indicated.
15. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked wither with each other or with exterior devices.
16. Communication Capability: Integral communication module with functions and features compatible with power monitoring system specified in Section 26 0913 – Electrical Power Monitoring and Control.
17. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground fault protection function, and/or short time function.
18. Listed for 100% of breaker's continuous ampere rating.

B. Circuit Breaker Electronic Trip Units general characteristics:
1. Circuit breakers, with solid-state microprocessor based trip units:
   a. Unit shall consist of current sensors, solid-state trip device, and solid-state adjustable time/current curve shaping elements.
   b. Trip units shall be removable to allow for field upgrades.
   c. Trip units shall incorporate "True RMS Sensing."
2. Solid-state elements shall provide functions as indicated above.
3. Adjustments shall be made using non-removable, discrete steps.
4. Sealable transparent cover shall be provided over adjustments.
5. Adjustable long-time pickup (Ir) and delay shall be available in an adjustable rating plug that is UL listed as field-replaceable. Adjustable rating plug shall allow for five minimum long-time pickup settings from 0.4 to 1.0 times the sensor plug (In). Other adjustable rating plugs shall be available for more precise settings to match the application. Long-time delay settings shall be at least three bands.
6. Short-time pickup shall allow for five minimum settings from 1.5 to 10 times Ir. Short-time delay shall be at least three bands with I^2t ON and OFF.
7. Instantaneous settings on the trip units shall be available in five minimum bands from 2 to 15 times In. The instantaneous settings shall also have an OFF setting when short-time pickup is provided.
8. Trip units shall have the capability to electronically adjust the settings locally and remotely to fine increments below the switch settings. Fine increments for pickup adjustments are to be one ampere. Fine increments for delay adjustments are to be one second.
9. Trip unit shall indicate:
   a. Long-time fault
   b. Short-time fault
   c. Instantaneous fault
   d. Ground fault, where provided
10. Trip unit shall provide local trip indication and capability to indicate local and remote reason for trip, i.e., overload, short circuit or ground fault.
11. Trip unit shall contain means to conduct circuit breaker tests, or via separate test kit.
12. Breaker shall be equipped with externally accessible test points to be used for field testing.
13. Trip units shall be available to provide real time metering. Metering functions include current, voltage, power and frequency.
14. Trip units shall be provided with the following standard features:
   a. True RMS sensing

b. LI
c. LSI
d. LSIG/Ground-fault trip
e. Ground Fault Alarm (no trip), with external relay, where required
f. Adjustable rating plugs
g. LCD or LED – Long-time pickup
h. LCD or LED – Trip indication
i. Digital Ammeter
j. Communications
k. LCD dot matrix display
l. Advanced user interface
m. Protective relay functions
n. Neutral protection
o. Incremental fine tuning of settings
p. Selectable long-time delay bands
q. Power measurement
r. Maximum peak demand (measure of average power over a 15-minute period) continuously recorded over a one-year period

2.8 The trip unit shall be equipped to permit communication via Modbus TCP connection(s) for interfacing to the BAS. The trip unit shall be provided with an address register for identification on the network. All monitored values shall be transmittable over the network. Electrical Metering.

a. BAS Control contractor and Electrical Metering provider shall be responsible for coordination of gateway requirements if needed, translation of network protocols, testing of communications between systems, and joint commissioning of systems.

B. Ground Fault protection equipment on breakers, where indicated: Integrally mounted relay and trip unit, push-to-test feature and ground fault indicator:

1. Ground-fault protection with at least three adjustable short-time-delay settings and three trip-time-delay bands; adjustable current pickup with maximum setting of 1200 A. Arrange to provide protection for the following:
   a. Three-wire circuit or system
   b. Four-wire circuit or system
   c. Four-wire, double-ended substation
2. Trip units shall be modified differential. Ground-fault sensing systems shall be changed in the field.
3. Neutral current transformers shall be provided for 4-wire system.
4. Ground-fault settings for circuit breaker sensor sizes 1200 A or below shall be in nine bands from 0.2 to 1.0 times In. The ground-fault settings for circuit breakers above 1200 A shall be in minimum three bands up to 1200 A.
5. Ground-Fault Relay: UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and 3-phase current transformer/sensor.

2.9 CONTROL POWER, COMPONENTS IDENTIFICATION, AND CONTROL WIRING

A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer: Dry-type transformers in separate compartments for units larger than 3 KVA, including primary and secondary fuses.

B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120 V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

D. Control components mounted within assembly, such as relays, pushbuttons, switches, etc.: Suitably marked for identification, corresponding to appropriate designations on manufacturer's wiring diagrams.

E. Control Wiring: Factory installed, with bundling, lacing, and protection included; flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units; insulated locking spade terminals for control connections, except where saddle type terminals, integral to a device; current transformer secondary leads, connected to short circuit terminal blocks; terminal blocks with suitable numbering strips for group of control wires leaving switchgear, with wire markers at each end of control wiring.

2.10 ACCESSORY COMPONENTS AND FEATURES

A. Furnish portable test set to test functions of circuit breakers and solid-state trip devices without removal from switchgear. Include relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.

B. Furnish accessory set including tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

C. Furnish one portable, floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

D. Furnish overhead circuit-breaker lifting devices, mounted at top front of switchgear, with hoist and lifting yokes matching each drawout circuit breaker.

E. Furnish set of tools for manually charging circuit breaker stored energy device.

F. Furnish racking handle to manually move circuit breaker between connected and disconnected positions.

G. Lockout Devices: Circuit breakers with integral, lock-out/tag-out devices.

2.11 SWITCHGEAR METERING

A. Per requirements in Section 26 09 13 – Electrical Power Metering

PART 3 - EXECUTION

3.1 COORDINATION

A. Instruct manufacturer about the location of incoming lugs, i.e., top or bottom feed based on incoming feeder entrance location.

B. Coordinate installation of housekeeping concrete pad based on actual equipment supplied:
   1. Concrete: Per requirements in Division 03 – Concrete.
   2. Dimensions: Per requirements in Section 26 0529 – Hangers and Supports for Electrical Systems.

C. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.

D. Verify with manufacturer that "touch-up" paint kit is available for repainting.

3.2 EXAMINATION

A. Examine areas and surface to receive switchgear for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Verify that space indicated for switchgear mounting meets code-required working clearances.

C. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

A. Install switchgear in accordance with applicable portions of ANSI/NECA 400.

B. Switchgear mounting and seismic restraints:

1. Install switchgear anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State, and to comply with Section 26 0548 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
2. Bolt switchgear to concrete housekeeping pads, using anchor bolts in accordance with Section 26 0529 – Hangers and Supports for Electrical Systems. Cast anchor bolt inserts into pads.
3. Install bushing assemblies for anchor bolts for seismic restraints per requirements in Section 26 0548 – Vibration and Seismic Controls for Electrical Systems.

C. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification for switchgear, every instrument, overcurrent protective device and disconnect device. Attach nameplate to exterior of switchgear using small corrosion-resistant metal screws and rivets. Do not use contact adhesive. Indicate switchgear manufacturer's name and drawing number, name, amperage, voltage, phase, number of wires, short circuit current rating (amp, RMS symmetrical and MVA 3-phase symmetrical) and momentary and fault-closing ratings (amp, RMS asymmetrical). For each overcurrent protective device and disconnect device, include circuit, load and area served, voltage/phase rating, and fuse size and type, when applicable.

D. Provide framed, printed operating instructions for switchgear, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of switchgear.

E. Install switchgear in dedicated electrical space per NFPA 70, and as indicated on drawings.

F. Tighten electrical connectors and terminal according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

G. Install fuses in fusible switch at job site per requirements in Section 26 2813 – Fuses.

H. Install surge arrestors in cable termination compartments and connect to each phase of circuit, per requirements in Section 26 4300 – Transient Voltage Suppression.

I. Connect transient voltage surge suppressors to switchgear bus per requirements in Section 26 4300 – Transient Voltage Suppression.

J. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

K. Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.4 CONNECTIONS

A. Ground switchgear according to Section 26 0526 – Grounding and Bonding for Electrical Systems.

B. Connect power and control wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

3.5 FIELD QUALITY CONTROL

A. Inspect switchgear for physical damage, proper alignment, connections, anchorage, seismic restraints and grounding.

B. Test continuity of each circuit.

C. Test switchgear per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

D. Interpret test results in writing and submit to Engineer.

E. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.6 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.

B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Laboratory.

3.7 ADJUSTING

A. Set field-adjustable circuit breakers trip settings, to values indicated on drawings or recommended by the overcurrent protective device coordination study per Section 26 0573 – Overcurrent Protective Device Coordination Study.

B. Field adjustments of trip setting and adjustment or replacement of equipment to comply with Section 26 0573 – Overcurrent Protective Device Coordination Study; no additional cost to Laboratory.

3.8 CLEANING

A. Clean switchgear during construction phase, prior to initial testing and energization, and prior to final punch list, after other trades have departed. Cleaning procedures shall be as follows:
   1. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.
   2. Rack out circuit breakers and remove arc chutes.
   3. Wipe down surfaces, including arc chutes and circuit breakers with Endust or equivalent.
   4. Use paintbrush to dust small, hard-to-reach crevices.

3.9 DEMONSTRATION

A. Provide training session by manufacturer for one workday at a job location, to train the Laboratory's personnel in the operation and maintenance of switchgear.

3.10 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

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SECTION 26 24 16.13

LIGHTING AND APPLIANCE PANELBOARDS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems

C. Section 26 05 29 – Hangers and Supports for Electrical Systems

D. Section 26 05 33 – Raceway and Boxes for Electrical Systems

E. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems

F. Section 26 05 53 – Electrical Systems Identification

G. Section 26 08 12 – Power Distribution Acceptance Tests

H. Section 26 08 13 – Power Distribution Acceptance Test Tables

I. Section 26 43 00 - Transient Voltage Suppression

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes circuit breaker type lighting and appliance branch circuit panelboards as shown on drawings and as scheduled.

1.4 REFERENCE STANDARDS

A. NECA 407 - Recommended Practice for Installing and Maintaining Panelboards

B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)

C. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

D. NEMA PB 1 - Panelboards

E. NEMA PB 1.1 - General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less

F. NFPA 70 - National Electrical Code

G. UL 50 - Cabinets and Boxes

H. UL 67 - Panelboards

I. UL 486A-486B - Wire Connectors

J. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

K. UL 869A - Reference Standard for Service Equipment

1.5 SUBMITTALS

A. Product Data:
   1. Submit catalog data showing specified features of standard products. Eliminate extraneous catalog data.

B. Shop Drawings:
   1. Submit for review prior to manufacture. Include complete description, front view, dimensions, voltage, main bus ampacity, circuit breaker arrangement and sizes, short circuit current rating, and factory settings of individual protective devices.
   2. Submit 1/4” scale electrical room floor plans with panelboard locations.

C. Partial Submittals:
   1. Panelboards shall be submitted for review together. Partial submittals of panelboards are not acceptable and will be rejected.

D. Manufacturer’s Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

E. Test Reports:
   1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

F. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations of panelboards and record actual circuiting arrangements.
   2. Operation and Maintenance Data:
      a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include manufacturer’s written instructions for testing and adjusting overcurrent protective devices.
      c. Include time-current curves and selectable ranges for each type of overcurrent protective device.
      d. Include spare parts data listing, source, and current prices of replacement parts and supplies.
      e. Include manufacturer’s Seismic Qualification Certification and Installation Seismic Qualification Certification.

1.6 QUALITY ASSURANCE

A. Obtain panelboards, overcurrent protective devices, components, and accessories from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.

B. Comply with NEMA PB 1.1 and manufacturer's written instructions.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.9 MAINTENANCE

A. Extra Materials:
   1. Furnish Laboratory with two keys per panelboard.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D

B. General Electric

C. Cutler Hammer

D. Siemens

2.2 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. NEMA PB 1, UL 67

B. Fabrication:
   1. Factory assembled.
   2. With door.
   3. Incoming feeder lugs: copper conductors.
   4. Multiple lugs to match number of conductors per phase.
   5. Sub-feed (double) lugs, or feed-through lugs where indicated.
   6. Filler plates.
   7. Wiring terminals for field installed conductors: Pressure wire connectors, except wire-binding screws for No. 10 AWG or smaller conductors.

C. Panelboard Buses:
   1. Copper
   2. Ampere rating as scheduled
   3. Ground bus: uninsulated, bonded to panelboard cabinet
   4. Insulated neutral bus: 100% of phase bus rating

D. Molded-Case Circuit Breakers:
   1. NEMA AB 1, UL 489
   2. Bolt-on type, labeled for 75°C copper and aluminum conductors
   3. Quick-make, quick-break, with thermal-magnetic trip.
   4. Common internal trip on multi-pole breakers. Handle-ties are not permitted.
   5. Ampere rating as scheduled
   6. Listed as Type SWD for lighting circuits
   7. Listed as Type HACR for air conditioning equipment circuits
   8. Bussing, device mounting hardware, and steel knockouts in dead front where “space” is indicated
   9. Tandem circuit breakers are not acceptable
   10. Ground fault equipment protection (GFEP), rated 30 mA trip, to provide equipment protection for branch circuits feeding electrical heat tracing, where indicated
   11. Ground fault circuit interrupter (GFCI), rated at 4-6 mA trip for protection of personnel, where indicated

E. Cabinet
   1. NEMA 250, UL 50
   2. NEMA Type 1 enclosure.
   3. Front (trim) surface mounted with door in front with concealed self-adjusting trim clamps, and complete with cylinder-type lock and catch. Trim front shall meet strength and rigidity requirements per UL 50 standards. Surface mounted panel front shall have ANSI 49 gray enamel electrodeposited over cleaned phosphatized steel. Recessed/flush mounted panel front shall have prime coat over cleaned phosphatized steel prepared for field painting. Recessed/flush mounted panel front shall have no exposed hinges. Panel to be field painted to match adjacent finishes..
   4. Same height matching trim, where two cabinets are mounted adjacent to one another in finished areas.
   5. All sections of panelboards have the same size, where oversize cabinets are required for one section of multi-section panelboard.
   6. Boxes and fronts made of code-gauge galvanized steel.
   7. Manufacturer’s standard gray enamel finish over prime coat for surface mounted panels.

2.3 SERVICE ENTRANCE

A. UL 869A

B. Panelboards labeled as suitable for use as service entrance equipment where applicable and must include connection for bonding and grounding of neutral conductor.

2.4 SHORT CIRCUIT CURRENT RATING

A. Each panelboard with minimum short circuit current rating as indicated on schedules.

B. Panelboards marked with their maximum short circuit current rating at supply voltage.

C. Panelboards: Fully rated.

D. 480Y/277V lighting panelboards with fuses provided upstream as indicated to achieve interrupting capacity indicated. Fuses located next to lighting panelboards.

2.5 TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS)

A. As indicated on drawings and as scheduled.

B. Per requirements in Section 26 4300 – Transient Voltage Suppression.

2.6 SPARE CONDUITS

A. Spare conduits per requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.

PART 3 - EXECUTION

3.1 COORDINATION WITH MANUFACTURER

A. Instruct manufacturer about the location of additional wiring gutter space when required (i.e., top, bottom, right, left, or combination).

B. Instruct manufacturer about the location of main lugs or main circuit breaker (i.e., top or bottom feed based on incoming feeder entrance location).

C. Instruct manufacturer to provide multiple lugs where conductors in parallel or sub-feed (double) lugs or feed-through lugs are indicated.

D. Instruct manufacturer on the size of cross-connection cables for panelboards fed via sub-feed (double) lugs or feed-through lugs. Make cable size with ampacity equal to incoming feeder.

E. Verify that “touch-up” paint kit is available for repainting.

3.2 EXAMINATION

A. Verify that space indicated for panelboard mounting meets code-required working clearances and dedicated equipment space.

B. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

A. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.

B. Install panelboards plumb and rigid without distortion of box, in accordance with manufacturer's written instructions, and in compliance with recognized industry practices.

C. Panelboard mounting and seismic restraints:
   1. Install panelboard anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State, and to comply with Section 26 0548 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
   2. Fasten panelboards firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
   3. Anchor and fasten panelboards and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 0529 – Hangers and Supports for Electrical Systems.
   4. Install two rows of steel slotted channel, with a minimum of 4 attachment points, for each panelboard section.
   5. When not located directly on wall, provide support frame of steel slotted channel anchored to floor and ceiling structure.

D. Install top breaker handle a maximum of 6’-7” above finished floor or working platform with handle in its highest position.

E. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A – 486B.

F. Install as-built typewritten circuit directory in directory frame (to indicate installed circuit loads) mounted inside each panelboard door. Include description of connected loads, room number, room name, area, or item served for each branch circuit. Indicate motor names and horsepower as applicable. Cover circuit directory with colorless plastic.

G. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to exterior of each panelboard using small metal screws or rivets. Do not use contact adhesive.

1. Include panelboard name, amperage, voltage, phase, and number of wires.

H. Label spare circuits as SPARE. Leave spare breakers in OFF position.

I. Room numbers used shall be those used by Laboratory except as otherwise directed by Architect.

J. Install panelboard in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.

K. Install filler plates in unused spaces.

L. Install three 3/4" spare conduits stubbed into accessible ceiling space or space designated to be ceiling space in the future for all flush-mounted panelboards. Install conduits in accordance with requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.

M. Install three 3/4" spare conduits stubbed into ceiling space above and below for panelboards that serve loads on levels other than that where the panelboard is located. Install conduits in accordance with requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.

3.4 CONNECTIONS

A. Ground panelboards according to Section 26 0526 – Grounding and Bonding for Electrical Systems.

B. Connect wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

3.5 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment, anchorage, and grounding.

B. Maintain proper phasing for multi-wire circuits.

C. Test main circuit breakers in accordance with requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

D. Interpret test results in writing and submit to Engineer.

3.6 REPAINTING

A. Remove paint splatters or other marks from surface of panelboards.

B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Laboratory.

C. Flush mounted panels located in finished spaces should be painted to match associated wall finish color.

3.7 ADJUSTING

A. Adjust fronts, covers, hinges, and locks.

3.8 CLEANING

A. Clean panelboard interiors and exteriors prior to final inspection. Remove paint splatters and other spots, dirt and debris.

End of Section

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SECTION 26 24 16.16

DISTRIBUTION PANELBOARDS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems

C. Section 26 05 29 – Hangers and Supports for Electrical Systems

D. Section 26 05 53 – Electrical Systems Identification

E. Section 26 08 12 – Power Distribution Acceptance Tests

F. Section 26 08 13 – Power Distribution Acceptance Test Tables

G. Section 26 43 00 – Transient Voltage Suppression

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes circuit breaker type and fusible switch type power distribution panelboards as shown on drawings and as scheduled.

1.4 REFERENCE STANDARDS

A. NECA 407 - Recommended Practice for Installing and Maintaining Panelboards

B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)

C. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

D. NEMA FU 1 - Low-Voltage Cartridge Fuses

E. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)

F. NEMA PB 1 - Panelboards

G. NEMA PB 1.1 - General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less

H. NFPA 70 - National Electrical Code

I. UL 50 - Cabinets and Boxes

J. UL 67 - Panelboards

K. UL 486A – 486B - Wire Connectors

L. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

M. UL 512 - Fuseholders

N. UL 869A - Reference Standard for Service Equipment

1.5 SUBMITTALS

A. Product Data:
   1. Submit catalog data showing specified features of standard products. Eliminate extraneous catalog data.

B. Shop Drawings:
   1. Submit for review prior to manufacture. Include complete description, front view, dimensions, voltage, main bus ampacity, circuit breaker arrangement and sizes, short circuit current rating, and factory settings of individual protective devices.
   2. Submit 1/4” scale electrical room floor plans with panelboard locations.
   3. Submit features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Partial Submittals:
   1. Panelboards shall be submitted for review together. Partial submittals of panelboards are not acceptable and will be rejected.

D. Manufacturer’s Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

E. Test Report:
   1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

F. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations of panelboards and record actual circuiting arrangements.
   2. Operation and Maintenance Data:
      a. Include manufacturer’s recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include manufacturer’s written instructions for testing and adjusting overcurrent protective devices.
      c. Include time-current curves and selectable ranges for each type of overcurrent protective device.
      d. Include spare parts data listing, source, and current prices of replacement parts and supplies.
      e. Include manufacturer’s Seismic Qualification Certification and Installation Seismic Qualification Certification.

1.6 QUALITY ASSURANCE

A. Obtain panelboards, overcurrent protective devices, components, and accessories from one source and by a single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70.

2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.

B. Comply with NEMA PB 1.1 and manufacturer's written instructions.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.9 MAINTENANCE

A. Extra Materials:
1. Furnish Laboratory with two keys per panelboard.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D

B. General Electric

C. Cutler Hammer

D. Siemens

2.2 POWER DISTRIBUTION PANELBOARDS

A. NEMA PB 1, UL 67.

B. Fabrication:
1. Factory assembled
2. Individualized breaker dead-front cover construction
3. Incoming feeder lugs: copper conductors
4. Multiple lugs to match number of conductors per phase
5. Sub-feed (double) lugs, or feed-through lugs where indicated
6. Filler plates
7. Wiring terminals for field installed conductors: Pressure wire connectors, except wire-binding screws for No. 10 AWG or smaller conductors.

C. Panelboard Buses:
1. Copper
2. Ampere rating as scheduled
3. Ground bus: uninsulated, bonded to panelboard cabinet

D. Molded-Case Circuit Breakers:
   1. NEMA AB 1, UL 489
   2. Bolt-on or I-line type, labeled for 167°F copper and aluminum conductors
   3. Quick-make, quick-break, with thermal-magnetic trip and electronic (solid-state microprocessor-based) trip
   4. Equipped with individually insulated, braced, and protected connectors
   5. Common internal trip on multi-pole breakers. Handle-ties are not permitted.
   6. Ampere rating as scheduled
   7. Front face flush with each other
   8. Large, permanent, individual circuit numbers affixed to each breaker in uniform position
   9. Tripped indication clearly shown by breaker handle taking position between “ON” and “OFF.”
   10. Listed as Type HACR for air conditioning equipment circuits
   11. Bussing, device mounting hardware, and steel knockouts in dead front where “space” is indicated
   12. For 225A frame size and below: thermal-magnetic trip
   13. For 250A frame size and above: electronic trip units interchangeable in the field within the frame size and field-adjustable long time pick-up, instantaneous current settings. Each adjustment shall have discrete settings and shall be independent of all other adjustments.

E. Fusible Switches:
   1. NEMA KS1, NEMA FU1, UL 512
   2. Labeled for 167°F conductors
   3. Quick-make quick-break with visible blades, externally operable handle and dual horsepower ratings.
   4. Handles to physically indicate “ON” and “OFF” position.
   5. Lockable only in “OFF” position and accept three industrial type heavy-duty padlocks.
   6. Covers and handles be interlocked to prevent opening in “ON” position, with means to permit release of interlock.
   7. Large permanent individual circuit numbers affixed to each fusible switch in uniform position.
   8. Rejection clips for Class R fuses specified.
   9. Provisions for Class J or Class L fuses, as applicable.
   10. Fuses: Per requirements in Section 26 2813 – Fuses.

F. Cabinet
   1. NEMA 250, UL 50
   2. NEMA Type 1, enclosure.
   3. Same height matching trim, where two cabinets are mounted adjacent to one another in finished areas.
   4. All sections of panelboards have the same size, where oversize cabinets are required for one section of multi-section panelboard.
   5. Boxes and fronts made of code-gauge galvanized steel
   6. Manufacturer’s standard gray enamel finish over prime coat.

2.3 SHORT CIRCUIT CURRENT RATING

A. Each panelboard with minimum short circuit current rating as indicated on drawings.

B. Panelboards marked with their maximum short circuit current rating at supply voltage.

C. Panelboards: Fully rated. Series-rated panelboards are not acceptable.

2.4 TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS)

A. As indicated on drawings and as scheduled.

B. Per requirements in Section 26 4300 – Transient Voltage Suppression.

PART 3 - EXECUTION

3.1 COORDINATION WITH MANUFACTURER

A. Instruct manufacturer about the location of additional wiring gutter space when required, i.e. top, bottom, right, left, or combination.

B. Instruct manufacturer about the location of main lugs or main circuit breaker (i.e., top or bottom feed based on incoming feeder entrance location).

C. Instruct manufacturer to provide multiple lugs where conductors in parallel or sub-feed (double) lugs or feed-through lugs are indicated.

D. Instruct manufacturer on the size of cross-connection cables for panelboards fed via sub-feed (double) lugs or feed-through lugs. Make cable size with ampacity equal to incoming feeder.

E. Verify that “touch-up” paint kit is available for repainting.

3.2 EXAMINATION

A. Verify that space indicated for panelboard mounting meets code-required working clearances and dedicated equipment space.

B. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

A. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.

B. Install panelboards plumb and rigid without distortion of box, in accordance with manufacturer's written instructions, and in compliance with recognized industry practices.

C. Panelboard mounting and seismic restraints:
   1. Install panelboard anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State, and to comply with Section 26 0548 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
   2. Fasten panelboards firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
   3. Anchor and fasten panelboards and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 0529 – Hangers and Supports for Electrical Systems.
   4. Install two rows of steel slotted channel, with a minimum of four attachment points, for each panelboard section.
   5. When not located directly on wall, provide support frame of steel slotted channel anchored to floor and ceiling structure.

D. Install top breaker handle a maximum of 6’-7” above finished floor or working platform, with handle in its highest position.

E. Tighten electrical connectors and terminals according to equipment manufacturer's published torque tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A – 486B.

F. Install as-built typewritten circuit directory in directory frame (to indicate installed circuit loads before completing load balancing) mounted inside each panelboard door. Include description of connected loads, room number, room name, area, or item served for each branch circuit. Indicate motor names and horsepower as applicable. Cover circuit directory with colorless plastic.

G. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to exterior of each panelboard using small, corrosion-resistant metal screws or rivets. Do not use contact adhesive.

1. Indicate panelboard name, amperage, voltage, phase, and number of wires.

H. Label spare circuits as SPARE. Leave spare breakers in OFF position.

I. Room numbers used shall be those used by Laboratory except as otherwise directed by Architect.

J. Install panelboard in dedicated electrical space per NFPA 70 and as shown on drawings. Coordinate with miscellaneous trades for equipment foreign to the electrical installation to be outside of dedicated electrical space.

K. Install filler plates in unused spaces.

L. Install fuses in fusible switches, per requirements in Section 26 2813 – Fuses.

3.4 CONNECTIONS

A. Ground panelboards according to Section 26 0526 – Grounding and Bonding for Electrical Systems.

B. Connect wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

3.5 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment, anchorage, and grounding.

B. Test circuit breakers per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

C. Interpret test results in writing and submit to Engineer.

3.6 REPAINTING

A. Remove paint splatters or other marks from surface of panelboards.

B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint to Laboratory.

3.7 ADJUSTING

A. Adjust fronts, covers, hinges, and locks.

B. Circuit Breakers: Set field-adjustable trip settings or change the trip settings, as indicated on drawings

3.8 CLEANING

A. Clean panelboard interiors and exteriors prior to final inspection. Remove paint splatters and other spots, dirt and debris.

End of Section

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SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 26 - Grounding and Bonding for Electrical Systems

B. Section 26 05 53 - Electrical Systems Identification

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes general-use snap switches, wall-box dimmers, fan speed controls, receptacles, hazardous (classified) location receptacles, pendant cord-connector devices, cord and plug sets and device cover plates.

1.4 REFERENCE STANDARDS

A. IEEE C62.41.2 – Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits

B. IEEE C62.45 – Surge Testing for Equipment Connected to Low-Voltage (1000V and less) AC Power Circuits

C. NECA 1 – Good Workmanship in Electrical Contracting

D. NFPA 70 – National Electrical Code

E. NFPA 99 –Health Care Facilities

F. NEMA FB 11 – Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations

G. NEMA WD-1 – General Color Requirements for Wiring Devices

H. NEMA WD-6 – Wiring Devices - Dimensional Requirements

I. NEMA 250 – Enclosures for Electrical Equipment (1000 Volts Maximum)

J. UL 20 – General-Use Snap Switches

K. UL 498 – Attachment Plugs and Receptacles

L. UL 943 – Ground-Fault Circuit-Interrupters

M. UL 1010 – Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations

N. UL 1436 – Outlet Circuit Testers and Similar Indicating Devices

O. UL 1449 – Transient Voltage Surge Suppressors

P. UL 1472 – Solid-State Dimming Controls

Q. UL 1917 – Solid-State Fan Speed Controls

1.5 SUBMITTALS

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

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

D. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

E. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

F. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations and ratings of wiring devices.
   2. Operation and Maintenance Data:
      a. Include in manufacturers' packing label warnings and instruction manuals with labeling conditions.
      b. Include source and current prices of replacement parts and supplies.

1.6 QUALITY ASSURANCE

A. Obtain wiring devices from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory unopened packaging until ready for installation.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.9 MAINTENANCE

A. Extra Materials: Furnish extra materials described below that match products installed, are packaged with protective covering for storage, and are identified with labels describing contents.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Cooper Wiring Devices; a division of Cooper Industries, Inc.

B. Hubbell Incorporated; Wiring Device-Kellems

C. Leviton Manufacturing Company, Inc.

D. Pass & Seymour/Legrand; Wiring Devices & Accessories

2.2 GENERAL-USE SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches: Heavy-duty (specification grade); back and side wired; flush or surface mounting; Body and Handle: thermoplastic with handle; for connection to copper or copper-clad conductors:
   1. Ratings:
      a. Voltage: 120-277V, AC
      b. Current: 20 A
   2. Single pole
   3. Three-way
   4. Four-way

2.3 RECEPTACLES

A. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, NEMA WD 6 configuration 6-15R, NEMA WD 6 configuration, NEMA WD 6 configuration 6-20R, NEMA WD 6 configuration 6-30R, NEMA WD 6 configuration 5-20R & 6-20R and UL 498.

B. Receptacles: 125 V, 20A, heavy-duty (specification grade); back and side wired; flush or surface mounted; straight blade; 2 pole, 3 wire grounding; thermoplastic body; duplex as indicated on drawings.
   1. Ground Fault Circuit Interrupter (GFCI):
      a. Additional compliance with UL 943 Class A.
      b. Leakage current trip level: 4 to 6 mA.
      c. Trip time: .025 seconds nominal.
      d. Non-feed through type
      e. Reverse line-load function to prevent GFCI from functioning if wired incorrectly.
      f. Indicator Light: Lighted when device is tripped.
   2. Isolated Ground (IG):
      a. Ground strap isolated from mounting strap.
      b. Ground screw connected directly to ground contacts.
   3. Twist-locking:
      a. NEMA WD 6 configuration L5-20R.
      b. NEMA WD 6 configuration L5-30R.
      c. NEMA WD 6 configuration L6-15R.
      d. NEMA WD 6 configuration L6-20R.

4. NEMA WD 6 configuration L6-30R.Special Purpose Receptacles: Specification grade, rated for voltage, amperage and NEMA configuration as noted on drawings.

2.4 PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configuration L5-20P and L5-20R, heavy-duty grade.
   1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
   2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.5 CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
   1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30%.
   2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.6 DEVICE COVER PLATES

A. Single and combination types to match corresponding wiring devices:
   1. Attachment: Metal screws with head color to match plate finish.
   2. Material for Finished Spaces 0.035” thick, satin-finished stainless steel.
   3. Material for Unfinished Spaces: Galvanized steel.
   4. Material for Damp Locations: Cast aluminum with while-in-use hinged cover, and listed and labeled for use in “wet locations.”

B. Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant thermoplastic with weatherproof while-in-use hinged cover.

2.7 FINISHES

A. Color:
   1. Switch handles, receptacle faceplates, and device cover plates: 0.035” thick, satin-finished stainless steel, except as follows:
      a. Switch handles and receptacle faceplates connected to Emergency or Standby Power System: Red; labeled “Emergency.”
      b. Isolated-Ground Receptacles: Orange
      c. UPS Receptacles: Gray

PART 3 - EXECUTION

3.1 COORDINATION

A. Special Purpose Receptacles: Coordinate final selections of NEMA configuration (locking, straight, blade, etc.) with configuration of plug on utilization equipment.

B. Receptacles for Laboratory-furnished equipment and equipment furnished under other divisions of specifications: Match plug configurations.

C. Cord and Plug Sets: Match equipment requirements.

D. Coordination with Other Trades:
   1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers guided by riding against outside of the boxes.
   2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
   3. Install device boxes in brick or block walls so that the device cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
   4. Install wiring devices after all wall preparation, including painting, is complete.

3.2 EXAMINATION

A. Verify location of wiring devices with architectural interior elevation drawings, prior to rough-in.

B. Verify outlet boxes are installed at proper height.

C. Verify wall openings are neatly cut and completely covered by wall plates.

D. Verify branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.3 PREPARATION

A. Clean debris from outlet boxes.

3.4 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise scheduled or indicated on drawings. Indicated dimensions are to center of device.

B. Conductors:
   1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
   2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   3. Length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
   4. Do not place bare stranded conductors directly under device screws. Use crimp on fork terminals for device terminations.

C. Device Installation:
   1. Replace all devices that have been in temporary use during construction or show signs of installation prior to completion of building finishing operations.
   2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   3. Do not remove surface protection, such as plastic film and smudge covers, until last possible moment.
   4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
   5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
   6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
   7. When conductors larger than No. 12 AWG are installed on 15A or 20A circuits, splice No. 12 AWG pigtails for device connections.
   8. Tighten unused terminal screws on the device.

9. When mounting into metal boxes, remove fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
10. Install devices plumb, level with finished surfaces and free from blemishes.
11. Install lighting switches vertically on latch side of door within 6” of frame edge.
12. Install devices above counters, 2” to the bottom of device above countertop or backsplash. Install all devices at same height above any one counter or fixed cabinet.
13. Install special purpose receptacles and switches according to shop and rough-in drawings furnished by trade(s) producing such equipment. Verify locations prior to rough-in.
14. Install weatherproof GFCI receptacles:
    a. Within 25’-0” of roof-mounted mechanical equipment
    b. Outdoors
    c. As indicated on drawings
15. Group adjacent switches under single, multigang wall plates.
16. Connect wiring device grounding terminal to outlet box with bonding jumper. Ground per requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.

D. Installation Orientations:
1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.
3. Install switches with handle operating vertically, with “ON” position up.
4. Unless otherwise indicated or where space problem occurs, mount devices flush, with long dimension vertical.

E. Device Cover Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

F. Wall-Box Dimmers:
1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers’ device listing conditions in the written instructions.

G. Arrangement of Devices:
1. Unless otherwise indicated or where space problem occurs, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

3.5 IDENTIFICATION

A. Comply with Section 26 0553 – Electrical Systems Identification.
1. Switches and Receptacles: Use hot, stamped or engraved machine printing with [black] [white] [red]-filled lettering on face of cover plate, and durable wire markers or tags inside outlet boxes.
    a. Receptacles: Label shall indicate receptacle voltage, phase, and amperage at top of cover plate, and panel and circuit number at bottom of cover plate.
    b. Switches: Label shall indicate switch voltage, phase, and amperage at top of cover plate, and panel, circuit number and switch designation at bottom of cover plate.

3.6 FIELD QUALITY CONTROL

A. Inspect wiring devices for defects.

B. Operate wall switches with circuits energized and verify proper operation.

C. Verify receptacle device is energized.

D. Perform tests and prepare test reports:
   1. Test receptacle devices for proper polarity:
      a. Test every receptacle with receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot or neutral and hot open. Rewire receptacles with faults and retest.
   2. Test each GFCI receptacle device for proper operation:
      a. Perform testing using an instrument specifically designed and manufactured for testing ground-fault circuit interrupters. Apply the test to the receptacle. "TEST" button operation will not be acceptable as a substitute for this test. Replace receptacles that do not shut off power with 5/1000 A within 1/40 second and retest.
   3. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
   4. Test Instruments: Use instruments that comply with UL 1436.
   5. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

E. Tests for Convenience Receptacles:
   1. Line Voltage: Acceptable range is 105 V to 132 V.
   2. Percent Voltage Drop under 15A Load: A value of 5% or higher is not acceptable.
   3. Ground Impedance: Values of up to 2 ohms are acceptable.
   4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

F. Operational Tests: Demonstrate the operation of each switch with the systems fully energized and operating. Each switch shall be demonstrated three times.

G. Interpret test results in writing and submit to Engineer.

3.7 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

3.8 CLEANING

A. Remove excess plaster from interior of outlet boxes.

B. Clean devices and cover plates after painting is complete. Replace stained or improperly painted devices and cover plates.

End of Section

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SECTION 26 28 13

FUSES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 28 16 - Enclosed Switches and Circuit Breakers

B. Section 26 29 13 - Enclosed Controllers

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and section under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes nonrenewable cartridge fuses, rated 600V and less, for use in low-voltage power distribution system and spare fuse cabinet.

1.4 REFERENCE STANDARDS

A. NEMA FU 1 - Low Voltage Cartridge Fuses

B. UL 248-1 - Low Voltage Fuses - Part 1: General Requirements

C. UL 248-12 - Low-Voltage Fuses - Part 12: Class R Fuses

D. UL 512 - Fuseholders

1.5 SUBMITTALS

A. Product Data:
   1. Submit the following for each fuse type and size indicated:
      a. Manufacturer's technical data on features, performance, electrical characteristics, ratings, and dimensions.
      b. Time-current curves, coordination charts and tables, and related data.
      c. Let-through current curves for fuses with current-limiting characteristics.
      d. Fuse size for each elevator disconnect switch.

B. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual class, size, and location of fuses.

1.6 QUALITY ASSURANCE

A. Obtain fuses from one source and by single manufacturer.

B. Comply with NFPA 70 for components and installation.

1.7 MAINTENANCE

A. Extra Materials:
   1. Furnish to the Laboratory a quantity of spare fuses equal to XXX% of the total quantity of each fuse class and size installed, minimum of 3 of each fuse class and size.
   2. Furnish 2 fuse pullers for each size fuse.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Bussmann

B. Ferraz Shawmut

C. Littelfuse

D. Edison Fusegear

2.2 CARTRIDGE FUSES

A. NEMA FU 1, UL 248-1.

B. Characteristics: nonrenewable current-limiting cartridge fuse; current rating and class, as specified or indicated, and voltage rating consistent with circuit voltage.

C. Miscellaneous data:

UL Standard	Class	Volts	Amperage	Interrupting Rating (Amp RMS Sym.)
248-4	CC	600	0-30	200,000
248-5	G	600	0-20	100,000
248-5	G	480	25-60	100,000
248-8	J	600	0-600	200,000
248-10	L	600	601-6000	200,000
248-12	RK1	250 or 600	0-600	200,000
248-12	RK5	250 or 600	0-600	200,000
248-15	T	300	0-1200	200,000
248-15	T	600	0-800	200,000

2.3 FUSEBLOCKS

A. UL 512

B. Thermoplastic base with UL flammability 94VO

C. Clip reinforcing springs – 100A and above

D. 200,000 A RMS Sym withstand rating

E. Copper or aluminum connections

2.4 TOUCH SAFE FUSEHOLDERS

A. UL 512

B. Thermoplastic base with UL flammability 94VO

C. Cover over fuses

D. Neon indicator lamp: "ON" when fuse opens

2.5 SPARE FUSE CABINET

A. Wall-mounted sheet metal cabinet with shelves, suitably sized to store spare fuses and fuse pullers specified with 10% capacity minimum.

B. Doors shall be hinged, with hasp for Laboratory's padlock.

C. Finish shall be gray enamel.

D. Cabinet shall have nameplate engraved "Spare Fuses" in 1/2" letters on door.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

3.2 INSTALLATION

A. Verify proper fuse locations, sizes, and characteristics.

B. Install fuses in fusible devices – Enclosed Switches and Circuit Breakers, and 26 2913 – Enclosed Controllers at job site.

C. Arrange fuses so manufacturer, class, and size are readable without removing fuse.

D. Install typewritten labels on inside door of each fused device, indicating fuse replacement information.

E. Install spare fuse cabinet as indicated on drawings.

3.3 APPLICATION

A. Motor Branch Circuits: Class RK1.

3.4 CLEANING

A. Clean fuses and tighten connections prior to energizing of equipment.

End of Section

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SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems

C. Section 26 05 29 – Hangers and Supports for Electrical Systems

D. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems

E. Section 26 05 53 – Electrical Systems Identification

F. Section 26 08 12 – Power Distribution Acceptance Tests

G. Section 26 08 13 – Power Distribution Acceptance Test Tables

H. Section 26 28 13 – Fuses

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes fusible and non-fusible disconnect switches and circuit breakers in individual enclosures.

1.4 REFERENCE STANDARDS

A. ANSI//NECA 1 - Standard Practices for Good Workmanship in Electrical Contracting

B. NEMA AB 1 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures

C. NEMA KS 1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)

D. NFPA 70 - National Electrical Code

E. UL 98 - Enclosed and Dead Front Switches

F. UL 486A - 468B - Wire Connectors

G. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures

H. UL 869A - Reference Standard for Service Equipment

1.5 SUBMITTALS

A. Product Data:

1. Submit catalog cut sheet indicating voltage, amperage, HP ratings, enclosure type, and dimension, fuse clip features, terminal lugs and all accessories including interlock devices, short circuit current ampere rating and factory settings of individual protective devices.

B. Manufacturer's Installation Instructions:
1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

C. Test Reports:
1. Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

D. Closeout Submittals:
1. Project Record Documents:
a. Record actual locations of disconnect switches and ratings of installed fuses.
b. Record actual locations and continuous current ratings of enclosed circuit breakers.
2. Operation and Maintenance Data:
a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
b. Include spare parts data listing, source, and current prices of replacement parts and supplies.
c. Include Manufacturer's Seismic Qualification Certification and Installation Seismic Qualification Certification.

1.6 QUALITY ASSURANCE

A. Obtain disconnect switches and enclosed circuit breakers from one source and by single manufacturer.

B. Regulatory Requirements:
1. Comply with NFPA 70 for components and installation.
2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect from dirt, water, construction debris, and traffic.

B. Comply with manufacturer's written instructions.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr written warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D

B. General Electric

C. Cutler-Hammer

D. Siemens

2.2 DISCONNECT SWITCHES

A. NEMA KS 1, UL 98

B. Load interrupter enclosed knife switch, heavy-duty type.

C. Fusible or non-fusible type as indicated.

D. Switch Interiors:
1. Switch blades that are visible in "OFF" position when switch door is open.
2. Plated current carrying parts.
3. Removable arc suppressors to permit easy access to line side lugs.

E. Switch Mechanism:
1. Quick-make, quick-break, with visible blades and externally operable handle.
2. Lockable only in “OFF” position and accept three industrial type, heavy-duty padlocks.
3. Dual cover interlock to prevent unauthorized opening of switch door when handle is in "ON" position, and to prevent closing of switch mechanism with door open.
4. Defeater mechanism to bypass interlock.
5. Operating handle integral part of enclosure.
6. Handle to physically indicate "ON" and "OFF" position.

F. Ratings:
1. Ampacity as indicated on drawings.
2. Horsepower rated.

G. Fusible Switches:
1. Rejection clips for Class R fuses specified.
2. Provisions for Class J or Class L fuses, as applicable.
3. Fuses: Per requirements in Section 26 2813 – Fuses.

2.3 ENCLOSED CIRCUIT BREAKERS

A. NEMA AB 1, UL 489.

B. Enclosed molded-case circuit breakers:
1. Tripped indication clearly shown on breaker handle taking position between “ON” and “OFF”.
2. 225A frame size and below: thermal-magnetic trip.

3. 250A frame size and above: electronic (solid-state microprocessor-based) trip units interchangeable in the field within the frame size and field-adjustable long time pick-up, long time delay, short time pick-up, short time delay, and instantaneous current settings. Each adjustment shall have discrete settings and shall be independent of other adjustments.

C. Breaker Mechanism:
1. Quick-make, quick-break.

D. Ratings:
1. Ampacity as indicated on drawings.
2. Listed as Type HACR for air conditioning equipment circuits.
3. Listed as Type SWD for lighting circuits.

2.4 LUGS

A. Front removable lugs.

B. Labeled for 75°C copper and aluminum conductors.

C. Multiple lugs to match number of conductors per phase.

D. Termination of field installed conductors: Pressure wire connectors, except wire-binding screws for No. 10 AWG or smaller conductors.

2.5 ACCESSORIES:

A. Solid neutral assembly, where required.

B. Equipment ground kit.

C. Blown fuse indicators on fused disconnect switches.

D. Factory installed fuse puller on fused disconnect switches.

E. One set of normally open (NO) auxiliary contacts, where disconnect switch is installed at a remote motor served by variable frequency drive (VFD).

2.6 ENCLOSURES

A. NEMA KS 1, NEMA AB 1, UL 98, UL 489, as applicable.

B. NEMA Type 1, Type 3R (outdoor locations) enclosure.

C. Code-gauge galvanized steel.

D. Manufacturer’s standard gray enamel finish over prime coat.

E. Surface-mounted.

2.7 SERVICE ENTRANCE

A. UL 869A

B. Switches and circuit breakers identified for use as service entrance equipment are to be labeled for this application, provided with solid neutral assembly and equipment ground bar, and must include connection for bonding and grounding of neutral conductor.

2.8 SHORT CIRCUIT CURRENT RATING

A. Each circuit breaker shall have minimum short circuit current rating as indicated on drawings.

PART 3 - EXECUTION

3.1 COORDINATION WITH MANUFACTURER

A. Instruct manufacturer about the location of incoming lugs, i.e., top or bottom feed based on incoming feeder entrance location.

B. Verify that “touch-up” paint kit is available for repainting.

3.2 EXAMINATION

A. Examine areas and surface to receive disconnect switches and enclosed circuit breakers for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Verify that space indicated for disconnect switches and enclosed circuit breakers mounting meets code-required working clearances.

C. Notify Architect/Engineer of any discrepancies prior to submittal of product data and shop drawings.

3.3 INSTALLATION

A. Install disconnect switches and/or enclosed circuit breakers in accordance with ANSI/NECA 1.

B. Install disconnect switches and/or enclosed circuit breakers level and plumb, in accordance with manufacturer’s written instruction.

C. Disconnect switches and enclosed circuit breakers mounting and seismic restraints:

1. Install disconnect switches and enclosed circuit breakers anchorage devices and seismic restraints based on design by an Engineer registered and licensed in the State, and to comply with Section 26 0548 – Vibration and Seismic Controls for Electrical Systems for seismic criteria.
2. Fasten disconnect switches and enclosed circuit breakers firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
3. Anchor and fasten disconnect switches and enclosed circuit breakers and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 0529 – Hangers and Supports for Electrical Systems.
4. Install two rows of steel slotted channel, with a minimum of four attachment points, for each disconnect switch and enclosed circuit breaker.
5. When not located directly on wall, install support frame of steel slotted channel anchored to floor and ceiling structure.

D. Do not support disconnect switches and/or enclosed circuit breakers by raceway.

E. Install top disconnect switch and/or enclosed circuit breaker handle a maximum of 6’-6” above finished floor.

F. Tighten electrical connectors and terminals according to equipment manufacturer's published torque-tightening values. Where manufacturer’s torque values are not indicated, use those specified in UL 486A - 486B.

G. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to exterior of each switch and/or enclosed circuit breaker using small corrosion-resistant metal screws or rivets. Do not use contact adhesive.

1. Include switch and/or enclosed circuit breaker name, amperage, voltage, phase, and number of wires.

H. Install fuses in fusible switches at job site per requirements in Section 26 2813 – Fuses.

3.4 CONNECTIONS

A. Ground equipment according to Section 26 0526 – Grounding and Bonding for Electrical Systems.

B. Connect wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

3.5 FIELD QUALITY CONTROL

A. Inspect for physical damage, proper alignment connections, anchorage, and grounding.

B. Correct malfunctioning units on-site and retest to demonstrate compliance. Remove and replace with new units and retest.

C. Test disconnect switches and/or enclosed circuit breakers per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

D. Interpret test results in writing and submit to Engineer.

3.6 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.

B. Touch-up chips, scratches, or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Laboratory.

3.7 ADJUSTING

A. Circuit Breakers: Set field-adjustable trip settings or change the trip settings, as indicated on drawings.

3.8 CLEANING

A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

End of Section

SECTION 26 29 13

ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 19 – Low-Voltage Electrical Power Conductors and Cables

B. Section 26 05 26 – Grounding and Bonding for Electrical Systems

C. Section 26 05 29 – Hangers and Supports for Electrical Systems

D. Section 26 05 33 – Raceway and Boxes for Electrical Systems

E. Section 26 05 53 – Electrical Systems Identification

F. Section 26 08 12 – Power Distribution Acceptance Tests

G. Section 26 08 13 – Power Distribution Acceptance Test Tables

H. Section 26 28 13 – Fuses

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes enclosed manual and magnetic motor controllers and enclosed contactors.

B. Motors shown on the drawings or specified in other Divisions of these specifications shall be provided with motorized equipment and connected under this section. Provide motor controllers and power circuit disconnect devices for all motors, unless shown or specified to be furnished with motorized equipment under other Divisions of these specifications, and/or by others, for installation by this contract.

C. Variable-frequency controllers furnished by Division 20 for installation by Division 26.

D. Motor Voltage Information:

1. Voltages available are: 208, 240 as indicated on the drawings, and 480 V, 3-phase and 120, 208 and 277V single phase. Circuits are designed for motors with voltage ratings as follows:
   a. Smaller than 1/2 hp motors: 115 V, single phase.
   b. 1/2 hp motors and larger: 200 and 460 V, 3-phase.

1.4 REFERENCE STANDARDS

A. ANSI/NECA 1 – Standard Practices for Good Workmanship in Electrical Contracting

B. NEMA AB 1 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures

C. NEMA 250 – Enclosures for Electrical Equipment (1000 V Maximum)

D. NEMA ICS 2 – Industrial Control and Systems: Controllers, Contactors and Overload Relays, Rated Not More Than 2000 VAC or 750 VDC

E. NEMA ICS 4 – Industrial Control and Systems: Terminal Blocks

F. NEMA ICS 5 – Industrial Control and Systems: Control Circuit and Pilot Devices

G. NEMA ICS 6 – Industrial Control and Systems: Enclosures

H. NEMA KS 1 – Enclosed and Miscellaneous Distribution Equipment Switches (600 V Maximum)

I. NEMA MG 1 – Motors and Generators

J. NFPA 70 – National Electrical Code

K. UL 98 – Enclosed and Dead Front Switches

L. UL 486A-486B – Wire Connectors

M. UL 489 – Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breakers Enclosures

N. UL 508 – Industrial Control Equipment

1.5 SUBMITTALS

A. Product Data:
   1. Motor controllers: Submit catalog cut sheets showing voltage, size, rating and size of switching and overcurrent protective devices, dimensions, and enclosure details.
   2. Contactors: Submit catalog cut sheets showing voltage, size, current rating, dimensions, and enclosure details.
   3. Factory settings and time-current curves of individual protective devices.
   4. Confirm motor sizes and voltages with submittals of other Divisions of specifications, and/or by others, prior to Section submittals.

B. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and/or starting of product.

C. Test Reports: Indicate field test and inspection procedures and interpret test results and corrective action taken for compliance with specification requirements.

D. Closeout Submittals:
   1. Project Record Documents:
      a. Record actual locations and ratings of enclosed motor controllers and enclosed contactors.
   2. Operation and Maintenance Data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventive maintenance instructions.
      b. Include spare parts data listing, source, and current prices of replacement parts and supplies.

1.6 QUALITY ASSURANCE

A. Obtain motor controllers, and contactors from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, water, construction debris, and traffic.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

1.9 MAINTENANCE

A. Extra Materials: Furnish extra materials described below that match product installed, are packaged with protective covering for storage, and are identified with labels describing contents.
   1. Spare pilot lights: Furnish 1 spare lamp for every 5 installed units, but not less than 1 set of 3 of each kind.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D

B. General Electric

C. Cutler-Hammer

D. Siemens

E. Allen Bradley

2.2 MANUAL MOTOR CONTROLLERS

A. Description: NEMA ICS 2, AC general-purpose, Class A, manually operated, full-voltage controller for small motors, with bimetal type overload relay, red pilot light, (NO) (NC) auxiliary contact, and pushbutton operator.

2.3 FRACTIONAL-HORSEPOWER MANUAL CONTROLLERS

A. Description: NEMA ICS 2, AC general-purpose, Class A, manually operated, full-voltage controller for fractional horsepower induction motors, with bimetal type overload relay, (red) pilot light, and toggle operator.

2.4 MOTOR STARTING SWITCHES

A. Description: NEMA ICS 2, AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, without thermal overload unit, with (red) pilot light, and toggle operator.

2.5 FULL-VOLTAGE NON-REVERSING MAGNETIC MOTOR CONTROLLERS

A. Description: NEMA ICS 2, AC general-purpose, Class A, magnetic controller for induction motors rated in horsepower, three-phase and single-phase, as scheduled, except where single-phase motors scheduled to be provided with built-in overload elements:
   1. Size 1 minimum
   2. Control Voltage: 120 V, 60 Hz
   3. Overload Relays: NEMA ICS 2, solid-state bimetal, 1 overload relay per phase:
      a. Solid-state type:
         1) Class 10, 20, selectable inverse-time tripping characteristics.
         2) Non-volatile operating memory.
         3) 3:1 current adjustment range.
         4) Phase loss/phase unbalance protection.
         5) Ambient temperature insensitive.
         6) Self-powered.
         7) Manual reset. Automatic recent not acceptable.
         8) Manual trip.
         9) Visible trip indication.
      b. Bimetallic type:
         1) Class 10, 20, [30] inverse-time tripping characteristics.
         2) Manual reset.
         3) Ambient temperature compensated bimetallic.
         4) One normally open and one normally closed isolated auxiliary contract.
   4. Features:
      a. Auxiliary Contacts: NEMA ICS 2, normally open contacts in addition to seal-in contact.
      b. Pilot Lights NEMA ICS 5: push-to-test LED type.
      c. Hand-Off-Auto (H-O-A) Selector Switches: Rotary type.
      d. Control Power Transformers: 120V secondary, adequate capacity to operate connected pilot, indicating and control devices, plus 100% spare capacity in each motor controller, but not less than 100VA. Fused primary and secondary, and unfused leg of secondary bonded to enclosure.
      e. Terminals: NEMA ICS 4.
      f. Other accessories detailed or required by drawings.

2.6 COMBINATION CONTROLLERS

A. Factory-assembled motor controllers with externally operable disconnect, molded-case circuit breaker type, in common enclosure; means for locking disconnect handle and means for defeating cover interlock.
   1. Molded-case circuit breakers: NEMA AB 1 and UL 489; quick-make, quick-break with thermal-magnetic trip, electronic (solid-state microprocessor-based) trip, instantaneous trip (motor circuit protector); lockable with two padlocks and interlocked with cover in closed position.
      a. Thermal-magnetic trip: 225A frame and below.

b. Electronic trip: Interchangeable in the field within the frame size and field-adjustable long time pick-up and delay and instantaneous current settings: 250A frame size and above. Each adjustment shall have discrete settings and shall be independent of all other adjustments.

c. Instantaneous trip (motor circuit protector): Field adjustable, short circuit trip coordinated with motor locked-rotor amperes; will open the circuit at current exceeding 1300% or 1700% of motor full-load current.

2. Fusible Switch: NEMA KS 1 and UL 98; enclosed knife switch, heavy-duty type, external operable handle, clips or pads to accommodate specified fuses:

a. Rejection clips for Class R fuses.

b. Provisions for Class J or Class L fuses, as applicable.

c. Fuses: Per requirements in Section 26 2813 – Fuses.

2.7 REDUCED VOLTAGE MOTOR CONTROLLERS

A. Motor controllers for NEMA rated 200 V motors 25 hp and above.

B. Motor controllers for NEMA rated 460 V motors 60 hp and above.

2.8 SOLID-STATE REDUCED-VOLTAGE CONTROLLERS

A. Description: NEMA ICS 2, suitable for use with standard NEMA MG 1, Design B, polyphase, medium induction motors.

1. Power section consisting of 3 power modules, each with 2 thyristors connected in inverse parallel, and mounted on common, insulated base. Thyristors shall be connected in “six pulse” configuration.

2. Electrical

a. Input voltage: 480Volts ±10%

b. Input frequency: 60 Hz

c. Output voltage: 40 to 100% of input

d. Start (Voltage Ramp) time: 0.5 – 60 seconds

e. Current (torque) control 100% - 500%

3. Adjustable acceleration rate control (uses voltage or current ramp), and adjustable starting torque control (up to 500% current limitation for 20 seconds).

4. Surge suppressor in solid-state power circuits to provide 3-phase protection against damage from supply voltage surges 10% or more above nominal line voltage.

5. LED indicators to show motor and control status, including the following conditions:

a. Control power available

b. Controller on

c. Overload trip

d. Loss of phase

e. Shorted silicon-controlled rectifier

6. Automatic voltage-reduction controls to reduce voltage when motor is running at light load.

7. Motor running contactor operates automatically when full voltage is applied to motor.

2.9 MOTOR CONTROLLER ACCESSORIES

A. Factory installed devices in controller enclosure, unless otherwise indicated, as follows:

1. “On-Off” and “Start-Stop” pushbutton stations, pilot lights, selector switches: NEMA ICS 2, heavy duty, type.

2. 120 V control circuits and pilot light, unless noted otherwise.

3. Red pilot light to indicate motor operation.
4. Green pilot light to indicate motor stopped.
5. Minimum wire size for control circuits: #14 AWG.
6. Stop and Lockout Pushbutton Station: Momentary-break pushbutton station with a factory-applied hasp arranged so a padlock can be used to lock pushbutton in depressed position with control circuit open, where indicated.
7. Control Relays: Auxiliary and adjustable time-delay relays, where indicated:
   a. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hardwired connection, with adjustable undervoltage setting.
   b. Current-Sensing, Phase-Failure Relays: Solid-state sensing circuit with isolated output contacts for hardwired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40%, or loss of supply voltage, with adjustable response delay.

B. Control services: As scheduled on motor schedule or indicated.

2.10 GENERAL PURPOSE MAGNETIC CONTACTORS

A. Description: NEMA ICS 2, same as magnetic controllers, except without overload protection.

B. Poles: To match circuit configuration and control function.

C. Configuration: Electrically held

D. Contact Rating: Match branch circuit overcurrent protection.

2.11 LIGHTING MAGNETIC CONTACTORS

A. Description: NEMA ICS 2, same as magnetic controller, except without overload protection.

B. Poles: To match circuit configuration and control function.

C. Configuration: Electrically held

D. Contact Rating: Match branch circuit overcurrent protection.

2.12 LUGS

A. Labeled for 75°C copper and aluminum conductors.

B. Multiple lugs to match number of conductors per phase.

C. Termination of field installed conductors: Pressure wire connectors, except wire-binding screws for No. 10 AWG or smaller conductors.

D. For equipment specified in this section and for equipment furnished under other Divisions of this specification and/or by others.

2.13 MOTOR CONTROLLERS AND CONTACTOR ENCLOSURES

A. NEMA 250, NEMA 1CS 6.

B. NEMA Type 1, Type 3R (outdoor locations) enclosure.

C. Code-gauge galvanized steel.

D. Manufacturer’s standard gray enamel finish over prime coat.

E. Surface-mounted. Flush-mounted where indicated.

PART 3 - EXECUTION

3.1 COORDINATION

A. Coordinate motor control wiring with Division 23 of these specifications.

B. Coordinate motor sizes and voltages with submittals of other Divisions of these specifications and/or by others.

C. Verify with manufacturer that “touch-up” paint kit is available for repainting.

3.2 EXAMINATION

A. Examine areas and surface to receive motor controllers and contactors for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Verify that space indicated for motor controllers and contactors mounting meets code-required working clearances.

C. Notify Architect/Engineer of any discrepancies prior to submittal of product data.

3.3 INSTALLATION

A. Install motor controllers and contactors in accordance with ANSI/NECA 1.

B. Install level and plumb, in accordance with manufacturer’s written instruction.

C. Motor controllers and contactors mounting:
   1. Fasten motor controllers and contractors firmly to walls and structural surfaces, ensuring they are permanently and mechanically anchored.
   2. Anchor and fasten motor controllers and contactors and their supports to building structural elements (wood, concrete, masonry, hollow walls and nonstructural building surfaces) by the methods described in Section 26 0529 – Hangers and Supports for Electrical Systems.
   3. Install two rows of steel slotted channel, with minimum of four attachment points, for each motor controller and contactor.
   4. When not located directly on wall, install support frame of steel slotted channel anchored to floor and ceiling structure.
   5. Do not support motor controllers and contactors only by raceway.

D. Tighten electrical connectors and terminals according to equipment manufacturer’s published torque-tightening valves. Where manufacturer’s torque valves are not indicated, use those specified in UL 486A-486B.

E. Install engraved plastic nameplates under provisions of Section 26 0553 – Electrical Systems Identification. Attach nameplate to exterior of each motor controller and contactor, using small corrosion resistant metal screws or rivets. Do not use contact adhesive:
   1. Indicate motor served, nameplate horsepower, full load amperes, code letter, service factor, voltage/phase rating, and fuse size and type, when applicable.

F. Connect each motor terminal box to rigid conduit system with maximum 18” of flexible liquid-tight metal conduit. Install conduit per requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.

G. Check for proper rotation and phase relationship of each motor.

H. Install fuses in fusible switch at job site pre requirements in Section 26 2813 – Fuses.

I. Control Wiring Installation:
   1. Install wiring between motor control devices according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.
   2. Install motor control wiring in accordance with control wiring diagrams and in raceways where indicated or required by contract drawings.
   3. Bundle, train, and support wiring in enclosures.
   4. Connect hand-off-automatic switch and other automatic-control devices where applicable.
      a. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
      b. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 APPLICATION

A. Select features of each motor controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, and configuration of pilot device and control circuit affecting controller functions.

3.5 CONNECTIONS

A. Provide green wire ground through flexible conduit to interconnect motor frame and rigid conduit system.

B. Ground and bond motor controller and contactor enclosures according to Section 26 0526 – Grounding and Bonding for Electrical Systems.

C. Connect power and control wiring according to Section 26 0519 – Low-Voltage Electrical Power Conductors and Cables.

D. Connect control wiring for operation, control and supervision of motorized equipment as shown on drawings and/or specified in this and other Divisions of these specifications.

3.6 FIELD QUALITY CONTROL

A. Inspect motor controllers and contactors for physical damage, proper alignment, connections, anchorage, seismic restraints and grounding.

B. Correct malfunctioning motor controllers and contactors on-site and retest to demonstrate compliance. Remove and replace with new units and retest.

C. Test continuity of each circuit.

D. Test motor controllers per requirements in Sections 26 0812 – Power Distribution Acceptance Tests and 26 0813 – Power Distribution Acceptance Test Tables.

E. Interpret test results in writing and submit to Engineer.

3.7 REPAINTING

A. Remove paint splatters and other marks from surface of equipment.

B. Touch-up chips, scratches or marred finishes to match original finish, using manufacturer-supplied paint kit. Leave remaining paint with Laboratory.

3.8 ADJUSTING

A. Set field-adjustable circuit breakers trip settings or change the trip settings as indicated on drawings.

B. Adjust motor circuit protectors.

3.9 CLEANING

A. Vacuum dirt and construction debris from interior and exterior of equipment; do not use compressed air to assist in cleaning.

End of Section

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SECTION 26 33 53.13

EMERGENCY LIGHTING INVERTOR

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 00 00 - General Electrical Requirements

B. Section 26 26 00 - Power Distribution Units

C. Section 26 05 53 - Electrical Systems Identification

D. Section 26 09 23 - Lighting Control Devices

E. Section 26 24 16.13 - Lighting and Appliance Panelboards

F. Section 26 28 16 - Enclosed Switches and Circuit Breakers

G. Section 26 51 00 - Lighting Fixtures

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION OF SYSTEM

A. Provide a KVA as shown on plans single phase Emergency Lighting System to furnish regulated alternating current (AC) power. The system shall be UL listed to Underwriters' Laboratories standard 924.

B. Equipment and accessories furnished under the terms of this specification shall be the standard product of a single manufacturer

1.4 REFERENCE STANDARDS

A. ANSI/IEEE Standard C62.41 - Guide on Surge Voltages in AC Power Circuits Rated up to 600 V

B. FCC Part 15, Subpart J, Class A

C. NEMA PE 1 - Uninterruptible Power Systems

D. UL 1778 - Uninterruptible Power Supply Equipment

E. UL 924 - the Standard for Safety of Emergency Lighting and Power Equipment

1.5 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Chloride Systems CH2 Series

B. Liebert/Emerson

C. Controlled Power

D. General Electric

2.2 SYSTEM OPERATION

A. Normal:

1. The connected load shall be continuously powered by the filtered power of the double conversion system and upon failure of the utility input the load shall automatically continue to be powered via the system's battery and inverter for the specified time. Upon restoration of utility power, the system will automatically resume supplying the load with double conversion, filtered power. The system input power factor shall be corrected to 0.97 or greater.

B. Bypass Mode:

1. Under emergency operations, the microprocessor shall regulate the output voltage within ±2% of nominal at full load for the specified discharge period; and the frequency shall be within ±0.5% of nominal. Transfer back to Normal Mode shall be accomplished with no interruption in power to the critical loads.

C. Retransfer to Inverter:

1. Static transfer switch shall automatically retransfer the load back to the inverter after the inverter has returned to normal voltage and synchronizes with the alternate bypass source.

2.3 FABRICATION AND MANUFACTURER

A. Electrical Input:

1. Voltage Range 277 VAC + 5%,
2. Input power factor correcting to 0.97
3. Frequency range 60Hz, ±2.5Hz
4. Input harmonic current distortion < 5%THD
5. IEEE 587 ANSI C 62.41-1980 surge suppression

B. Bypass AC Input:

1. Voltage 277 VAC, ±10%, 1-phase, 2 wire plus equipment ground.
2. Frequency 60 Hz nominal ±5 Hz

C. Electrical Output:

1. Voltage 277 VAC
2. Voltage Regulation - frequency 60 Hz ± 2% nominal for any of the following conditions:
   a. No load to full load
   b. 1.0 to 0.8 lagging power factor

c. Minimum to maximum DC input voltage

d. 32ºF (0ºC) to 104ºF (40ºC)ambient temperature

3. Voltage Adjustment Range: ± 5% manually

D. System Overload:

1. Overload capability 150% for 1 minute with utility power source present.

E. Environmental Conditions:

1. Operating ambient temperature:

a. UPS Module 32° to 104°F

b. Battery 77° ±41°F

2. Non-operating and storage ambient temperature -4° to 158°F.

3. Relative humidity 0% to 95% for temperatures in the operating range without condensation.

F. Audible Noise:

1. Noise generated by the UPS under any condition of normal operation shall not exceed 65 dB measured at 3 ft from the nearest surface of the cabinet.

2.4 UPS MODULE

A. System display shall indicate normal, caution and alarm conditions.

B. Monitoring Capabilities:

1. Dry contact for remote failure alarm, and a DB9 computer style connector shall provide volt free contacts for remote alarm indication

2.5 BATTERY/CHARGER

A. Storage batteries shall be maintenance free, sealed lead calcium

B. Provide battery circuit breaker.

C. Solid state battery charger shall be completely automatic with a programmed reference, and capable of restoring the battery to capacity within UL 924 90 minute requirements. The charger shall have capability to recharge a battery of up to 4 hour discharge capacity and shall automatically maintain the battery in the fully charged condition whenever the utility power is available..

D. A low voltage disconnect circuit designed to reduce battery discharge during extended power outages, shall monitor the battery voltage and disconnect the inverter when battery voltage drops to approximately 85% of nominal voltage. Restoration of utility power following a low voltage disconnect event shall automatically re-start the system

2.6 CONSTRUCTION AND MOUNTING:

A. UPS shall be housed in NEMA Type 1 metal enclosures, designed for floor mounting.

B. UPS cabinets shall be painted with manufacturer's standard color.

C. Adequate ventilation shall be provided to insure that all components are operated within their environmental ratings.

D. Temperature sensors shall be provided to monitor temperature of critical components.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wiring shall be in accordance with manufacturer's recommendations.

B. Wiring shall be run in conduit.

C. Final connections and start-up shall be made by UPS factory representative.

D. Provide infrared scan of battery connections under full load test.

3.2 OWNER TRAINING

A. Contractor to provide training in start-up, operation, and maintenance of equipment supplied. Training to be conducted by factory-certified instructors.

B. Contractor to submit training plan for Owner's approval. Training plan to include duration of training sessions, suggested class size/attendees, locations, lesson objectives, and outline of training topics.

C. Contractor may, at request of Owner, be required to hold 2 separate training sessions to accommodate multiple personnel shifts.

3.3 TESTING REQUIREMENTS

A. Factory Testing:

1. UPS system shall be tested during manufacturing process to assure that equipment is fully functioning and its performance meets specifications. Upon request, manufacturer shall describe testing program and supply sample test procedures and test data sheets to document testing program.

B. Site Testing:

1. UPS equipment shall be fully tested after installation. Testing shall be part of start-up service provided by manufacturer. Site testing shall include complete inspection of installation to assure it was performed in accordance with manufacturer's recommendations.

End of Section

SECTION 26 36 23

AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 00 00 – General Electrical Requirements

B. Section 26 05 29 – Hangers and Supports for Electrical Systems

C. Section 26 05 48 – Vibration and Seismic Controls for Electrical Systems

D. Section 26 32 13 – Engine Generators

1.2 REFERENCE

A. Work under this section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 DESCRIPTION OF SYSTEM

A. Provide automatic transfer switch, 3 phase, 60 Hz, 3 pole, with solid neutral for voltage and current as indicated on drawings.

1.4 REFERENCE STANDARDS

A. ICS 10 Industrial Control and Systems Part 1: Electromechanical AC Transfer Switch Equipment

B. UL1008 Automatic Transfer Switches

1.5 SUBMITTALS

A. Submit shop Drawings for equipment provided under this Section.

1.6 QUALITY ASSURANCE

A. Obtain automatic transfer switches from one source and by single manufacturer.

B. Regulatory Requirements:
   1. Comply with NFPA 70 for components and installation.
   2. Furnish products listed and classified by Underwriters Laboratories, Inc., as suitable for purpose specified and indicated.

C. Factory Test
   1. Test system in accordance at the factory in accordance with Section 26 0812 - Power Distribution Acceptance Tests and Demonstration of Transfer Functions.
   2. Provide factory test report.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store in clean, dry space. Maintain factory wrapping or provide additional canvas or plastic cover to protect units from dirt, fumes, water, corrosive substances, construction debris, and traffic. Provide temporary heaters in switchgear as required to prevent condensation.

B. Deliver in (48") (XXX") maximum width shipping splits, individually wrapped for protection, and mounted on shipping skids. Mark crates, boxes, and cartons clearly to identify equipment. Show crate, box, or carton identification number on shipping invoices.

C. Use factory-installed lifting provisions. Handle carefully to avoid damage to internal components, enclosure, and finish.

1.8 WARRANTY

A. Refer to Division 01 and Section 26 0000 – General Electrical Requirements for general warranty requirements.

B. Manufacturer shall provide standard 1 yr warranty against defects in materials and workmanship for products specified in this Section. Warranty period shall begin on date of substantial completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Acceptable Manufacturers: Asco, Onan, Russelectric, or Zenith

2.2 AUTO-TRANSFER SWITCH

A. Auto-transfer switch:
   1. Mechanically held, electrically operated type
   2. Interlocked to ensure only 2 possible positions, normal and emergency.
   3. Rated for continuous duty in unventilated sheet metal enclosure
   4. Suitable for all classes of loads at maximum rated voltages
   5. Withstand rating that meets or exceeds withstand rating of transfer switch feeder breakers.

B. Provide main contacts with silver alloy wiping action type protected by arcing contacts.

C. Provide switch components accessible from front of enclosure.

D. Provide 10 cycle short circuit rating to guarantee contact opening and no damage. Transfer switch is served by power circuit breakers.

E. Provide switch with the following items:
   1. Adjustable 1 to 3 second time delay to override momentary voltage dips and outages.
   2. Time delay on transfer to emergency. Adjustable from 1 to 300 seconds (factory set at 3 seconds).
   3. Time delay on retransfer to normal. Adjustable from 2 seconds to 30 minutes.
   4. Full phase protection consisting of 2 phase relays and one close differential relay. Phase relays shall be set to 70% drop out, 90% pick up, and differential relays set for 92 to 95% pick-up and 83 to 85% drop-out.
   5. Pushbutton reset to normal.
   6. Pushbutton to bypass time delay on retransfer to normal.

7. Pilot light to indicate normal position.
8. Pilot light to indicate emergency position.
9. Auxiliary contact to close when normal power fails.
10. Auxiliary contact to open when normal power fails.
11. Auxiliary contact on same shaft as main contacts (closed on normal).
12. Auxiliary contact on same shaft as main contacts (closed on emergency).
13. Four position selector switch to provide "Test," "Auto," "OFF", and "Engine Start."
14. Contacts to start engine-generator when normal power fails.
15. Time delay engine start, adjustable from 0 to 5 seconds.
16. Adjustable time delay on retransfer to normal source with 5 minute unloaded running time of standby plant:
    a. Minimum delay 2 minutes
    b. Maximum delay 25 minutes
    c. Built in circuitry to nullify time delay if emergency source fails and power is available at normal source.
17. Relay to prevent transfer to emergency until voltage and frequency of generating plant have reached 90% of rated value.
18. Provide bi-direction in-phase monitor or dual motor operator with programmed neutral to allow voltage decay in motor and transformer circuits.

F. Bypass/isolation switch:
1. Dual-source enclosed.
2. Isolate transfer switch and de-energize for maintenance, testing or repair.
3. Dual-source operation - bypass either to normal or emergency source directly to load at discretion of operator.
4. Break-before-make operation of contacts.
5. Operation - fully mechanical, designed to provide quick-make-quick-break of contacts and only allow switch to be fully closed or fully open with no mid position possible.
6. Operation - possible regardless of the position or condition of the automatic transfer switch.

2.3 ELEVATOR CONTROL INTERFACE

A. Provide auxiliary contacts to provide emergency system status to elevator controller.

B. Contacts required are:
1. Emergency power signal
2. Pre-transfer warning signal

C. Pre-transfer warning signal relay to change state prior to operation of transfer switch in either direction.

D. These contacts are in addition to other required contacts.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install equipment in accordance with manufacturer's recommendations.

B. Provide equipment protection during and subsequent to installation.

C. Provide wiring between transfer switch and elevator controller. Final connections at elevator controller by Elevator Contractor.

D. Connect transfer switches that are part of fire pump controllers.

3.2 OPERATION

A. Parallel "start engine-generator" contacts of automatic transfer switches, such that failure of normal source at any switch shall start engine.

B. Transfer of one switch from normal to emergency shall not preclude any other switch from transferring.

C. Engine generator cool down cycle shall not start until all transfer switches have timed out back to normal source.

D. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

3.3 ACCEPTANCE TESTING

A. Perform acceptance testing in accordance with Section 26 0812 – Power Distribution Acceptance Tests.

B. Adjust or replace equipment as needed to comply with manufacturer's specifications and resubmit corrected test reports.

C. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

SECTION 26 41 13

LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 05 26 – Grounding and Bonding for Electrical Systems

B. Section 26 05 33 – Raceway and Boxes for Electrical Systems

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Section includes lightning protection systems consisting of air terminals, roof conductors, bonding conductors, down conductors, fastener connections, and grounding.

1.4 REFERENCE STANDARDS

A. ANSI/NEMA GR1 - Grounding Rod Electrodes and Ground Rod Electrode Couplings

B. NFPA 70 - National Electrical Code

C. NFPA 780 - Standard for the Installation of Lightning Protection Systems

D. UL 96 - Lightning Protection Components

E. UL 96A - Installation Requirements for Lightning Protection Systems

1.5 SUBMITTALS

A. Product Data:
   1. Submit manufacturer's descriptive and technical literature and catalog cuts.

B. Shop Drawings:
   1. Submit installation shop drawings for the overall lightning protection system. Include physical layout of the equipment, mounting details, and relationship to other parts of the work.
   2. Submit detail drawings for each major component.
   3. Submit location, size, and material of grounding electrodes, and connection type.
   4. Submit roof adhesive data for air terminals mounted on single-ply roofing.

C. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply roofing material.

D. Copy of Laboratory's UL Master Label Certificate.

E. Manufacturer's Installation Instructions:
   1. Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation.

F. Closeout Submittals:
   1. Project record documents:
      a. Record active location of lighting protection system components.
   2. Operation and maintenance data:
      a. Include manufacturer's recommended operating instructions, maintenance procedures and intervals, and preventative maintenance instructions.

1.6 QUALITY ASSURANCE

A. Qualifications:
   1. Lightning protection system materials:
      a. Consists of standard products by a manufacturer regularly engaged in production of lightning protection systems.
      b. UL Listed
   2. Lightning protection system installer: UL Listed.

B. Regulatory Requirements:
   1. Lightning protection system: Comply with NFPA 780, UL 96, and UL 96A.

C. Certifications:
   1. Furnish Laboratory with UL Master Label Certificate upon completion of installation providing proof that the lightning protection system is in compliance with UL 96 and UL 96A standards.

1.7 SEQUENCING

A. Coordinate installation of lightning protection with installation of other building systems and components, including supporting structures and building materials, metal bodies requiring bonding to lightning protection components, exterior and interior building finishes, and building roofing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Thompson Lightning Protection Company

B. Harger Lightning Protection, Inc.

C. Heary Brothers Lightning Protection Company, Inc.

D. National Lightning Protection Corporation

E. Erico International Corporation

F. Approved Equal

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. NFPA 780, UL 96.

B. Materials: Air terminals, main and cross-run roof conductors, bonding and down conductors, conductor fasteners, and connections: Class I:
   1. Air terminals:

a. Solid type with a blunt tip at perimeters, height and spacing as noted on drawings
b. Solid type with a blunt tip, safety protector and spring base at roof center, height and spacing as noted on drawings

2. ANSI/NEMA GR1 Grounding Electrodes: 3/4” x 10 ft long copper-clad steel ground rod.

C. Concrete-Encased Electrodes: As shown on drawings.

D. Ground Ring Electrode: As shown on drawings.

E. Ground Connectors:
1. Bronze of the clamp type and bronze clamp accessories.
2. Provide in accordance with the requirements in Section 26 0526 – Grounding and Bonding for Electrical Systems.

F. Galvanic Compatibility of Materials:
1. Air terminals, conductors, fasteners, and connectors shall be galvanically compatible with surfaces they are mounted to.
2. Copper materials in all locations except where the use of aluminum materials is necessary for galvanic compatibility.
3. Aluminum materials on copper roofs are not acceptable.
4. Aluminum materials where mounted on aluminum roofing, siding, or other aluminum surfaces.
5. Bimetallic fittings when joining metals that are not galvanically compatible.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lighting protection to comply with UL 96A, NFPA 70, and NFPA 780. Conform to the most stringent requirement in NFPA 780.

B. Bond exterior metals including flashing, roof drains, vent stacks, fans, water pipes, metal raceways, enclosures, frames, and other non-current carrying metal parts of electrical and mechanical equipment on roof to lightning protection system.

C. Bond lower end of exhaust ducts, vent stacks, etc., passing through roof.

D. Run bonding jumpers continuously horizontally or down from point of bond to point of connection to main conductor.

E. Make down conductors electrically continuous via direct connection to structural columns, with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops. Protect down conductors, where necessary, to prevent physical damage or displacement to the conductor. Use PVC Schedule 40 conduits. Provide conduits in accordance with requirements in Section 26 0533 – Raceway and Boxes for Electrical Systems.

F. Conceal system conductors and interior conductors.

G. Notify Architect at least 48 hours before concealing lightning protection system components.

H. Below-grade or concealed cable connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components.

I. Exposed cable connections: Use approved mechanical connections.

J. Air terminals mounted on single-ply roofing: Use adhesive recommended by manufacturer of air terminals and approved by manufacturer of roofing material. Comply with adhesive manufacturer's installation instructions. For roofing work, refer to Division 07 - Thermal and Moisture Protection. Provide patch where terminal adhesive is not compatible with roof membrane.

K. Attach each down conductor to structure and the grounding electrode by exothermic welding.

L. Provide grounding electrodes with top two feet below finished grade.

3.2 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the present of moisture, unless moisture is permanently excluded from the junction of such materials.

B. Use conductors with suitable protective coatings where conditions would cause deterioration or corrosion of conductors.

3.3 FIELD QUALITY CONTROL

A. Apply for inspection by Underwriters Laboratories, Inc. (UL) to obtain UL Master Label Certificate.

B. Verify that lightning protection surge arrestor devices are installed on all incoming power and communications lines, in order to obtain UL Master label Certificate.

C. Test grounding system to ensure continuity prior to backfilling and paving: Check that resistance to earth does not exceed 25 ohms, measured by "Fall-of-Potential" method.

D. Make resistance measurements in dry weather not earlier than 48 hours after rainfall.

E. Make visual inspection to verify that there are no loose connections that may result in high resistance joints, and conductors and system components are securely fastened to their mounting surfaces and are protected against accidental mechanical displacement.

End of Section

SECTION 26 43 00

SURGE PROTECTIVE DEVICES (SPD)

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 00 00 - General Electrical Requirements

B. Section 26 05 26 - Grounding and Bonding for Electrical Systems

C. Section 26 24 13 - Switchboards

D. Section 26 24 16.13 - Lighting and Appliance Panelboards

E. Section 26 24 16.16 - Distribution Panelboards

F. Section 26 27 26 - Wiring Devices

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.3 DESCRIPTION

A. Provide Type 2 Surge Protective Devices (SPD) for the protection of AC electrical circuits formerly known as Transient Voltage Surge Suppression (TVSS) System. Provide high energy surge current diversion and be suitable for application in Type 2 environments.

B. Modes of Protection:
   1. Line to Ground, Line to Neutral and Neutral to Ground for services with a neutral
   2. For Services without a neutral, Line to Line and Line to Ground

C. Provide common and normal modes of protection.

1.4 REFERENCE STANDARDS

A. ANSI C62.41 Recommended Practice for Surge Voltage in Low-Voltage AC Power Circuits

B. UL 1449 Surge Protective Devices Third Edition or Newer

C. IEEE 587

D. FIPS PUB 94

E. IEEE C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and less) AC Power Circuits

F. National Electrical Code – Article 285

G. National Fire Protection Association – NFPA 20, 70, 75, and 78

1.5 SUBMITTALS

A. Submit Shop Drawings for equipment provided under this Section.

B. Submit shop drawings and product information for approval and final documentation in quantities listed according to Conditions of the Contract. Transmittals shall identify customer name, customer location, and customer order number.

C. Submittals shall include UL 1449 Listing documentation to verify the following:
   1. Short Circuit Current Rating (SCCR)
   2. Voltage Protection Ratings (VPRs) for all modes
   3. Maximum Continuous Operating Voltage rating (MCOV)
   4. I-nominal rating (I-n)
   5. Type 2 device
   6. VPR, MCOV, I-n, and Type 2 information is posted at www.UL.com under Certifications; search using UL Category Code: VZCA. SCCRs are posted in manufacturer's published documentation.
   7. UL data and visual inspection takes precedence over manufacturer's published documentation.

D. Provide shop drawings including manufacturer installation instruction manual and line drawings detailing dimensions and weight of enclosure, internal wiring diagram illustrating all modes of protection in each type of SPD required, wiring diagram showing field connections, and manufacturer's recommended wire and breaker sizes (if required).

E. Upon request, an un-encapsulated SPD module shall be presented for visual inspection, proprietary technology included. MOV type and quantity shall reflect kA ratings on cutsheets, verification of diagnostic monitoring, thermal and overcurrent protection, etc.

PART 2 - PRODUCTS

2.1 MATERIAL

A. Acceptable manufacturers:
   1. APT
   2. Current Technology
   3. LEA
   4. Liebert
   5. Raycap

2.2 PERFORMANCE CHARACTERISTICS

A. Response time: > 5 nanoseconds for all modes of protection.

B. SPD shall bear the UL Mark and shall be Listed to Third Edition of UL 1449. "Manufactured in accordance with" is not equivalent to UL Listing and does not meet intent of specification.

C. Post SPD and performance parameters at www.UL.com under Category Code: VZCA. Products or parameter without posting at UL.com are not approved.

D. Minimum surge current capacity for Service Entrance units based on 8 x 20 microsecond current waveform:
   1. 200,000 A between each phase for line-to-line mode
   2. 200,000 A each phase for line-to-ground mode

3. 200,000 A each phase for line-to-neutral mode
4. 200,000 A for neutral-to-ground mode

E. Minimum surge current capacity for panelboard units based on 8 x 20 microsecond current waveform:
1. 100,000 A between each phase for line-to-line mode
2. 100,000 A each phase for line-to-ground mode
3. 100,000 A each phase for line-to-neutral mode
4. 100,000 A for neutral-to-ground mode

F. Sequential Surge Current Survivability:
1. 1,000 sequential category surges without failure.

G. Current Rating:
1. Rated for continuous current and AIC rating of equipment protected.

2.3 OPERATING CONDITIONS

A. Temperature range: -40°C to +50°C (-40°F to 122°F)

B. Relative humidity range: 0 to 95%, non-condensing

C. Audible noise level: > 40 dBA at 5 ft

2.4 FABRICATION

A. SPD Modules:
1. UL Labeled as Type 2 (verifiable at www.UL.com), intended for use without need for external or supplemental overcurrent controls. Protect suppression component of every mode, including N-G, by internal overcurrent and thermal overtemperature controls. SPDs relying on external or supplementary installed safety disconnects do not meet intent of specification.
2. UL Labeled with 20kA I-nominal (I-n) (verifiable at UL.com) for compliance to UL 96A Lightning Protection Mater label and NFPA 780.
3. Suppression components: Heavy-duty MOVs, selenium cells, or combination of both.
4. Provide surge current diversion paths for all modes of protection: L-N, L-G, N-G in WYE systems, and L-L, L-G in DELTA systems.
5. Provide service entrance SPD audible diagnostic monitoring by way of audible alarm.
6. Provide service entrance SPD with 1 set of NO/NC dry contacts for alarm conditions.
7. Provide visual LED diagnostics including a minimum of 1 green LED indicator per phase, and 1 red service LED. Include an audible alarm with on/off silence function and diagnostic test function (excluding branch).
8. If a dedicated breaker for the SPD is not provided in the switchboard, include an integral UL Recognized disconnect switch. Dedicated breaker to serve as a means of disconnect for distribution SPDs.
9. Meet or exceed the following criteria:
   a. UL 1449 Listed Voltage Protection Ratings (VPRs) for 6kV 3000A testing as follows:

VOLTAGE	L-N L-G N-G	L-L
208Y/120V	650-800V	650-800V
480Y/277V	1100-1300V	1900-2100V

10. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

System Voltage	Allowable System Voltage Fluctuation (%)	MCOV
208Y/120	15%	140V
480Y/277	15%	320V

11. Provide serviceable, replaceable modules (excluding Branch).
12. Provide warranty for a period of 10 yrs, incorporating unlimited replacements of suppressor parts if they are destroyed by transients during the warranty period.

B. Service Entrance:
1. Install 1 primary suppressor external to the service entrance in accordance with manufacturer instructions.
2. Install SPD on line or load side.
3. Bond SPD ground to service entrance ground.

C. Distribution Panelboards:
1. Install 1 suppressor external to each designated distribution panelboard.
2. Install surge suppression device in accordance with manufacturer instructions.

D. SPD High Performance Interconnect Cable (HPI):
1. Provide dual-shielded triple insulated multi-core power conductor cable specifically listed for SPD installations.
2. Low impedance approximately 25% of conventional pipe and wire for improved clamping voltage.

PART 3 - EXECUTION

3.1 APPLICATION OF SPD

A. Provide UL approved disconnect switch at Service Entrance or Transfer Switch as a means of service disconnect if a 60A breaker is not available.

B. Provide independent means of servicing disconnect at Distribution, MCC, and Branch such that the protected panel remains energized. A 30A breaker (or larger) may serve this function.

3.2 INSTALLATION

A. Install per manufacturer's recommended practices.

B. Provide short and straight conductors not exceeding 3 ft in length. Manufacturer-approved cables may be used that allow conductor length to extend beyond 3’-0” in length without affecting capability of unit.

C. Input conductors twisted together to reduce inductance.

D. Avoid 90-degree bends in cable.

3.3 QUALITY ASSURANCE

A. Factory test system before shipment. Include quality control check, "Hi-Pot" tests at 2 times rated voltage plus 1,000 V, ground leakage tests, and calibration.

B. Manufacturer Qualifications: Engage a firm with at least 5 yrs experience in manufacturing surge protective devices.

C. Manufacturer of equipment shall have produced similar electrical equipment for a minimum period of 5 yrs. When requested by Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with requirement.

D. Provide SPD compliant with the Restriction of Hazardous Substances (RoHS) Directive 2002/95/EC.

3.4 FIELD QUALITY CONTROL

A. Inspections before SPD startup:
   1. Visual Inspection:
      a. Verify installation per drawings.
      b. Verify phase, neutral, and ground conductors are properly sized and configured.
   2. Mechanical Inspection:
      a. Check connections for tightness.
      b. Check terminal screws, nuts and/or connectors for tightness.
   3. Electrical Inspection:
      a. Confirm input voltage.
      b. Confirm phase, neutral and ground connections are proper.

3.5 WARRANTY

A. Provide 10 yr manufacturer warranty.

End of Section

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SECTION 26 51 00

LIGHTING FIXTURES

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 26 00 00 - General Electrical Requirements

B. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables

C. Section 26 05 19.16 - Manufactured Wiring Systems

D. Section 26 05 26 - Grounding and Bonding for Electrical Systems

E. Section 26 05 33 - Raceway and Boxes for Electrical Systems

F. Section 26 09 23 - Lighting Control Devices

1.2 REFERENCE

A. Work under this Section is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 DESCRIPTION OF WORK

A. Provide luminaires as shown on Contract Drawing and Specifications.

B. Luminaires shall be provided complete with necessary accessories for proper installation.

C. Catalog numbers shown in luminaire schedule are basic luminaire types. Additional features, accessories and options specified or scheduled shall be included.

D. Provide lamps for luminaires as recommended by luminaire manufacturer and as scheduled.

E. Specifications and drawings convey the features, and functions of luminaires only and do not show every item or detail necessary for the work.

F. Work includes final aiming and focusing of luminaires under direction of the Architect/Engineer.

1.4 REFERENCE STANDARDS

A. NECA/IESNA 500 - Recommended Practice for Installing Indoor Commercial Lighting Systems (ANSI)

B. NECA/IESNA 501 - Recommended Practice for Installing Exterior Lighting Systems (ANSI)

C. NECD/IESNA 502 - Recommended Practice for Installing Industrial Lighting Systems (ANSI)

D. NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility

E. UL 57 - Electrical Luminaires

F. UL 496 - Lampholders

G. UL 773 - Plug-in Photocontrols for use with area lighting

H. UL 924 - Emergency Lighting and Power Equipment

I. UL 935 - Fluorescent Lamp Ballasts

J. UL 1029 - High Intensity Discharge Lamp Ballast

K. UL 1570 - Fluorescent Luminaire

L. UL 1571 - Incandescent Luminaire

M. UL 1572 - High Intensity Discharge Luminaire

N. UL 1598 - Luminaires

1.5 QUALITY ASSURANCE

A. Luminaire and accessory components shall be constructed of materials appropriate for their use.

B. Luminaires, ballasts, lamps and other components shall meet the requirements of all applicable State and Municipal energy codes.

C. Provide luminaires listed and labeled for their indicated use and installation conditions.

D. Contractor shall coordinate installation of lighting systems with all trades.
   1. Manufacturers listed in the luminaire schedule shall be assumed capable of supplying listed luminaires. Any such exceptions shall immediately be brought to the attention of Architect and Lighting Consultant. Multiple Name Specification:
      a. When multiple manufacturers are listed, Electrical Contractor shall choose which of the listed products are to be provided.
      b. Products of the same type shall be of same manufacturer.
   2. Single Name Specification:
      a. When only one product is suitable for the application and/or no other known acceptable products exist, only one manufacturer/product is listed in the Luminaire Schedule. For such instances, Electrical Contractor shall provide the listed product with no exceptions.
      b. Specifier has secured accurate pricing for all single name products prior to bidding and has shared this information with Architect/Laboratory's Representative. Contractor shall supply contractor net unit pricing for all single name products specified. Unit price shall be for equipment only and not include installation or miscellaneous electrical costs.

E. Substitution requests:
   1. Will be evaluated prior to Bid.
   2. Shall follow procedures set forth in this Section and in Section 01 2500 - Substitution Procedures.
   3. Shall be made not less than 14 days prior to bid date.
   4. Shall include the following information:
      a. Specified and proposed manufacturer's product data sheet, noting options and features.
      b. Provide dimensioned drawing of luminaire.

c. Provide photometric data in form of an electronic IES file on 3-1/2" floppy disk or CD, for use in a recognized computer lighting program.

5. Provide table-top samples and/or mockup of specified luminaire and proposed alternate.
6. Samples shall:
   a. Be fully operable, complete with specified lamp(s) and ready for installation.
   b. Remain available during construction.
7. Electrical Contractor shall be responsible for all costs incurred by substitution request sample and/or mockup production and review.
8. Equipment delivery lead time shall not be held as a valid reason for requesting luminaire substitution unless luminaire lead time from specified manufacturer is in excess of 14 weeks. It shall be the sole responsibility of the Electrical Contractor to determine necessary equipment lead times, deliver submittals for review in a timely fashion, and place orders accordingly to ensure timely delivery.
9. When requesting a substitution, Electrical Contractor shall provide unit and extended pricing for specified luminaire, unit and extended pricing for proposed alternate, and unit and extended delta savings to Laboratory to be realized by accepting proposed alternate. If requested, provide unit pricing for each luminaire type specified to provide a baseline comparison for substitution request.
10. Electrical Contractor shall guarantee pricing on all luminaire types for which a substitution request has been granted. This price guarantee shall be per unit and shall be maintained through the end of construction, regardless of quantity purchased.

1.6 SUBMITTALS

A. As soon as possible after award of Contract, submit complete list of lighting products to be furnished, with manufacturer and catalog designations, including currently quoted lead times for product delivery. Should Electrical Contractor anticipate delivery schedule of any specified product may adversely impact construction schedule, he shall bring it to the attention of the Laboratory at this time.

B. In addition to complying with requirements of Section 26 0000 - General Electrical Requirements, submittals shall include the following:
   1. Manufacturer's product data
   2. Installation instructions
   3. Maintenance data
   4. Parts list for each luminaire accessories
   5. Photometric Data: photometric data for luminaire, including optical performance as follows:
      a. Coefficients of utilization
      b. Luminance table
      c. Candela distribution data
      d. Zonal lumens
      e. Area and roadway luminaires shall include Isocandela Charts and IES Roadway Distribution Classification.
   6. Ballast schedule indicating manufacturer, type, and catalog number for each luminaire
   7. Ballast cut sheet for each ballast used, referencing luminaire type(s)
   8. Lamp schedule indicating manufacturer, type, and catalog number for each luminaire
   9. Lamp cut sheet for each lamp used, referencing luminaire type(s)
   10. Documentation of lamp and ballast compatibility
   11. Product color/finish
      a. Where specific finish or color is not specified and options exist, submit color or finish samples to Architect/Engineer for selection.

C. Shop Drawings for equipment provided under this Section shall include the following:
   1. Detailed drawings of linear and suspended luminaires including dimensions, support spacing, suspension type, power feed type and locations, lamp combinations, ballast locations, luminaire joint locations and end plates.
   2. Detailed drawings for each cove and linear wall system configuration including dimensions, power feed locations, ballast locations, luminaire joint locations, extension plates for end and corner sections and end plates.
   3. For fluorescent strip luminaires mounted in architectural coves, provide dimensioned drawings and sections and include louver/lens cut sheet.
   4. Detailed drawings for nonstandard luminaires indicating dimensions, weights, method of field assembly, components, features, and accessories. Details shall be scaled at not less than half full size.
   5. Photometric Data: Where indicated on luminaire schedule and Contract Drawings, supply complete photometric data for luminaire, including optical performance rendered by independent testing laboratory developed according to methods of the Illuminating Engineering Society of North America as follows:
      a. Coefficients of utilization
      b. Luminance table with data presented numerically, showing maximum luminaire luminance at shielding angles. Readings should be taken both crosswise and lengthwise in case of fluorescent luminaire or luminaire with an asymmetric distribution.
      c. Candela distribution data, presented graphically and numerically, in 5° increments (5°, 10°, 15°, etc.) Data developed for up and down quadrants normal, parallel, and at 11-1/2°, 45°, 67-1/2° to lamps if light output is asymmetric.
      d. Zonal lumens stated numerically in 10° increments (5°, 15°, etc.) as above.
      e. Area and roadway luminaires shall also include isocandela charts and IES roadway distribution classification.

D. Catalogue Cuts lacking sufficient detail will not be accepted.

E. No variation from the general arrangement and details indicated on drawings shall be made on shop drawings unless required by actual conditions. All variations shall be marked on drawings submitted for approval.

1.7 LUMINAIRE MOCK-UPS

A. Upon return of submittals, and prior to release for manufacturing, Contractor shall provide mock-up on site (or at another agreed upon location) in actual architectural conditions for review by Architect/Engineer and Laboratory.

B. Provide type and quantity of luminaires as requested by Architect/Engineer.

C. Mock-up shall include working luminaires and fastening devices.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Luminaires:
   1. As shown on Luminaire Schedule

B. Electronic Fluorescent Ballasts:
   1. Advance, GE, Motorola, Osram Sylvania, Robertson

C. Electronic Dimming Fluorescent Ballasts:
   1. Advance, Lutron, Motorola, Osram Sylvania

D. Emergency Fluorescent Ballasts:
   1. Bodine, Dual-Lite, Exide

E. Electronic HID Ballasts:
   1. Aromat
   2. Other manufacturers shall require preapproval.

F. Low Voltage Transformers:
   1. Q-Tran
   2. Other manufacturers shall require preapproval.

G. Lamps:
   1. General Electric, Osram Sylvania, Philips Lighting, Ushio

H. LEDs
   1. Lumileds
   2. Other manufacturers shall require preapproval.

2.2 FABRICATION AND MANUFACTURER

A. Luminaires:
   1. Construction
      a. Luminaires shall bear label indicating circuit voltage. Labels shall not be visible from normal viewing angles.
      b. Luminaires shall be constructed with joints made by means of welded, brazed, screwed, or bolted construction methods.
      c. Housings shall be so constructed that all electrical components are accessible and replaceable without removing luminaires from their mountings.
      d. Surface temperatures of luminaires with ballasts shall not exceed 194°F in 86°F ambient.
      e. Luminaires recessed in ceilings utilized as air handling plenums shall be certified as suitable for the purpose.
      f. Miter cuts shall be accurate, joints shall be flush and without burrs.
      g. Fluorescent troffers with doors shall have spring-loaded door cam latches.
      h. Provide inscription for exit and stairway signs to conform to applicable codes.
   2. Lenses, Reflectors and Diffusers
      a. All lenses or louvers shall be removable, but held so that normal motion will not cause them to drop out.
      b. All glass used in incandescent luminaires shall have thermal resistance characteristics equal to "Pyrex" glass.
      c. Optical lenses shall be free from spherical and chromatic aberrations.
      d. Acrylic lenses shall be 100% virgin acrylic material.
      e. Fluorescent troffer lenses shall be 0.125" thick, unless otherwise noted.
      f. Alzak reflectors and louvers shall be low iridescent equivalent to Coil Anodizers. All alzak parabolic cones shall be guaranteed against discoloration for a minimum of ten years.

g. Fluorescent luminaires installed without glass, acrylic or metal enclosure, shall be equipped with safety type lampholders. Provide wire guard.

3. Optics and Adjustments
   a. Lamp sockets shall be suitable for the indicated lamps and shall be set such that lamps are positioned in optically correct relation to all luminaire components.
   b. Spread Lens Luminaire: Luminaires with spread lens shall contain lens orientation locking devices to insure that lens orientation is not disturbed during future lamp replacement or cleaning.
   c. Oval Beam Luminaire: Luminaires with oval shape beam pattern lamps shall contain lamp orientation locking devices to insure that beam orientation is not disturbed during lamp replacement or cleaning.
   d. Adjustable Angle Luminaire: Luminaires with adjustment beam angle shall contain reliable angle locking devices.
4. Finishes
   a. Provide luminaires with finish as shown in the luminaire schedule. Verify final finish requirements before releasing luminaires for fabrication.
   b. Painted luminaires shall be painted after fabrication or "post painted".
   c. Ferrous parts and supports shall be rust proofed after fabrication.
5. Wiring
   a. Luminaires shall be completely wired at the factory.
   b. Internal wiring shall contain no splices.
   c. Connections shall be made with insulated "wire nut" type mechanical connectors.
   d. Wire for connections to lamp sockets and lamp auxiliaries shall be minimum #16 ga luminaire wire.
   e. Luminaires shall be provided with flexible conduit, pigtails, and equipment for external connections.
   f. Recessed incandescent luminaires shall incorporate integral thermal protection.
   g. Incandescent luminaires shall be wired with heat resistant wire.
   h. Recessed HID luminaires with integral ballasts, installed indoors, shall have thermal protection integral with ballast.
   i. Recessed luminaires installed in inaccessible ceilings shall be UL listed for through wiring with the junction box accessible from the luminaire opening.
   j. Provide dual-level switching for luminaires as indicated on luminaire schedule and where shown on Contract Drawings. Typically first switch designation controls outboard lamps, and second switch designation controls inboard lamp(s), unless noted otherwise.
   k. Provide lamps for all luminaires.
6. Support:
   a. Rigid metallic pipe stems shall be utilized for the support of pendant mounted luminaires, unless otherwise noted.
   b. Stem hangers shall be equipped with aligner box covers or canopies so that stems hang vertically, irrespective of the angle of the surface they are mounted from.
   c. Wherever a luminaire or its hanger canopy is attached to a surface mounted outlet box, a finishing ring shall conceal the outlet box.
   d. Yokes, brackets and supplementary supporting members needed to mount luminaires to suitable ceiling members shall be furnished and installed by Contractor. Verify mounting hardware required prior to installation.
7. Framing
   a. Verify type of ceiling construction prior to releasing luminaires for fabrication and delivery.

b. Provide mounting appurtenance, flanges, sloped ceiling adaptors where required.

c. Provide mounting assembly, clips or other mechanical mounting lugs as required for support of luminaires.

d. Light leaks between ceiling trim of recessed luminaires and ceilings are not allowed.

e. Ceiling opening frames shall be manufactured of non ferrous metal or be suitably rust proofed after fabrication.

f. Ceiling opening frames for recessed luminaires shall be furnished by Electrical Contractor and installed by General Contractor.

8. Outdoor Lighting Systems:

a. Luminaire schedule shows style of outdoor luminaires, pole heights and basic IESNA distribution patterns.

b. Provide poles as shown on luminaire schedule.

1). Poles shall have hand-holes.

2). Fusing for each luminaire head shall be located in hand-hole near base of pole.

3). Pole base anchor bolts shall be galvanized.

4). Poles shall be made of aluminum or steel.

c. Exterior Luminaires:

1). Shall operate at a minimum ambient temperature of 0°F.

2). Fully gasketed, with UL wet location label

3). Provide approved wire mesh screens for ventilation openings.

4). Anodized aluminum reflectors shall have minimum of 0.00079” mm anodizing thickness.

9. All castings and extrusions shall be given mimimum one coat of baked-on clear lacquer, unless painted finish is specified.

10. Aluminum surfaces shall receive a duronodic or polyester powder paint finish.

11. Cast-in Luminaire housings installed directly in concrete shall be fabricated of hot dip galvanized steel or cast aluminum or composite.

a. Where cast aluminum housings are used, give two coats of asphaltum paint prior to installation.

b. Provide 1/8” thick x 2” diameter solid neoprene grommets at each point light luminaire surfaces are mounted to concrete structure.

2.3 BALLASTS

A. Ballasts shall be equipped with line fuses.

1. Fuses shall be type and size recommended by luminaire manufacturer.

B. Ballasts shall be suitable for operating the indicated lamps.

C. Ballasts for use in cold or freezer rooms, loading docks, and outdoors shall be low temperature type.

1. Ballast shall have lowest temperature rating available in standard manufacture for its type.

D. Ballasts shall be located in luminaire they serve, unless otherwise noted.

E. Electronic Fluorescent Ballasts:

1. Compact fluorescent lamps, above 13 Watts, use only electronic programmed rapid start ballasts.

2. Linear fluorescent lamps, T8 and T5 type, shall use programmed rapid start electronic ballasts.

3. Multi-lamp programmed rapid start ballasts shall be of the series sequence type.

4. Ballasts shall be:

a. ETL Certified, CBM and UL Listed, and meet or exceed NEMA and ANSI Standards.

b. Class P thermally protected
c. Class A sound rated
d. Operate lamps as scheduled
e. Maintain constant light output over entire operating voltage range.
f. Operate lamps at frequency of 40 kHz or higher with less than 2% flicker.
g. Meet or exceed EMI and RFI limits set by FCC (Part 18).
h. Maintain the following performance:
   1). Lamp Current Crest Factor ≤ 1.6
   2). Total Harmonic Distortion ≤ 10%
   3). Power factor ≥ 0.90
   4). Ballast Factor = .85
i. Equipped with a cut-off circuit that senses over-voltage condition to lamp for end-of-life protection.
j. Ballast case temperature shall not exceed -4°F temperature rise over 104°F ambient.
k. Be equipped with a cut-off circuit that senses an over-voltage condition to lamp for end-of-life protection for all lamps smaller than one inch in diameter (all T2, T4 and T5 lamps).

F. Emergency Fluorescent Ballasts:
1. Shall operate 2 lamps at 60% output for minimum of 90 minutes.
2. Light output: 1100-1400 lumens
3. Nickel-cadmium battery Field replaceable
4. Installed inside luminaires.
5. Solid state charging
6. Battery to be recharged within 24 hrs.
7. Automatic testing every 30 days for 30 seconds and once a year for 90 minutes. Provide with flashing indicator light and audible alarm.

2.4 TRANSFORMERS

A. Transformers shall be:
1. Sized to compensate for voltage drop over indicated distances
2. Locally fused

B. Transformers shall have line voltage switch within reach.

C. Provide adequate ventilation to meet code and manufacturers requirements.

2.5 TANDEM WIRED LUMINAIRE PAIRS

A. Luminaires may be tandem wired in a master/slave configuration to minimize the use of single lamp ballasts or to minimize circuit connection points.

B. Tandem wiring shall consist of a UL Listed wiring system fabricated by the luminaire manufacturer to interconnect ballast wiring from the "master" luminaire to the unballasted "slave" luminaire.

C. Wiring shall be:
1. 12 AWG ga minimum
2. Enclosed in 3/8" diameter flexible metallic conduit.

D. Tandem wiring shall not be used for luminaires spaced greater than 10 ft apart (on center).

E. Support conduit with nylon tie wraps or metal clips.

2.6 LAMPS

A. Provide lamps as noted on Luminaire Schedule.

B. Provide lamps of same type from same manufacturer.

C. Where a specific lamp manufacturer has been indicated in the Luminaire Schedule, lamps shall be supplied from named manufacturer only.

D. Linear fluorescent lamps shall be:
   1. Rapid start
   2. Triphosphor
   3. Minimum CRI of 80
   4. Color temperature as noted on Luminaire Schedule

E. Compact fluorescent lamps shall be:
   1. Triphosphor
   2. Four pin
   3. Minimum CRI of 80
   4. Color temperature as noted on Luminaire Schedule

F. Metal halide lamps 100 watts or lower, shall be:
   1. Ceramic metal halide
   2. Minimum CRI of 80
   3. Color temperature as noted on Luminaire Schedule
   4. Color temperature shall not vary more than 200 Kelvin over rated lamp life.

G. Metal Halide lamps 150 watts or higher, shall be:
   1. Metal halide lamps
   2. Minimum CRI of 70
   3. Color temperature as noted on Luminaire Schedule
   4. Provide pulse-arc lamps when available.

H. Metal Halide Lamps shall have extinguishing mechanisms to terminate operation in event outer globe of lamp is broken, punctured, or missing.

I. Incandescent lamps shall be rated for 130-volt operation, except quartz lamps and lamps which are dimmed shall be rated for 120-volt operation.

J. Low voltage incandescent lamps, MR16 type, shall have 10,000 hour rated life at 12V and be Ushio Ultraline.

K. Provide all other lamp types and special purpose lamps as noted on Luminaire Schedule.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Marking:

1. Voltage identification: Luminaires designed for voltages other than 110-125 volt circuits shall be clearly marked with rated voltage.
2. Lamp/ballast coordination: Luminaires equipped with ballast for operation of rapid start lamps shall be plainly marked "Use Rapid Start Lamps Only". Similarly, luminaires equipped with ballasts or other components requiring use of specific types of lamps shall be plainly marked.
3. Markings must be clear and shall be located to be readily visible to service personnel but invisible from normal viewing angles when lamps are in place.

B. Installation of Luminaires:

1. Lamps, glassware, reflectors and refractors shall be clean and free of chips, cracks and scratches.
2. Install decorative luminaires, reflector cones, baffles, aperture plates, lenses, trims, and decorative elements of recessed luminaires after completion of ceiling tile, plastering, painting, and general cleanup is completed. Where luminaire location or construction does not permit sequential installation, all reflectors, lenses, flanges and other visible surfaces shall be carefully protected.
3. Locations
   a. Install luminaires at locations and heights as indicated.
   b. Do not scale electrical drawings for locations of luminaires.
   c. Architectural reflected ceiling plans show locations of luminaires.
   d. Where noted on the drawings, the exact location of luminaires shall be confirmed (in the field) with the Architect/Engineer prior to installation.
   e. Where luminaires are to be concealed, or surface mounted in highly visible public spaces, a small sampling of luminaires shall be installed, adjusted and aimed for Architect/Engineer's review approval, prior to installing remaining luminaire of same type.
   f. Mount all luminaires so as to maintain full range of motion.
   g. Install luminaires plumb, square, and level with ceilings and walls.
   h. Coordinate stem, rod, chain, or aircraft cable hanger lengths with job conditions.
   i. Industrial type luminaires in unfinished areas, which are near obstructions such as ducts and pipes, shall be:
      1). Suspended so that bottom of luminaire is no higher than bottom of obstruction
      2). Located at height of lowest luminaire
      3). Minimum height: 8'-0"
      4). Shall not be located until locations of obstructions are determined.
4. Support
   a. Support surface mount luminaires from building structure.
   b. Metal decking shall not be pierced for luminaire support.
   c. Provide luminaires and/or luminaire outlet boxes with hangers to support luminaire weight.
   d. Fluorescent troffers shall be held in place by support clips.
   e. Provide plaster frames for recessed luminaires in plaster ceilings.
   f. Recessed luminaires shall be supported with 12 ga wire hangers, 2 per luminaire, at diagonally opposite corners.

g. Recessed 4” x 4” fluorescent troffers and luminaires over 55 lbs shall be supported with 12 ga wire hangers, 4 per luminaire, 2 at 45 degree diagonals, and two perpendicular to structure. Wire hangers and attachment to structure shall be capable of supporting 4 times luminaires weight.

h. Surface luminaires installed in grid ceilings shall be supported by independent support clips and 12 ga wire.

i. Exit signs installed in grid ceilings shall be supported by electrical box hanger and additional 12 ga wire installed from box to structure.

j. Support surface mounted luminaires greater than 2 ft in length at a minimum of each additional 2 ft, or as recommended by manufacturer.

k. Brace suspended luminaires installed near ducts or other constructions with solid pendants or threaded rods.

l. Rigidly align continuous rows of luminaires.

m. Luminaire types with remote mounted ballast shall have:

1). Proper support for ballast weight.

2). Mounting distance from remote ballast to luminaire per manufacturer's recommendations.

5. Mounting and Enclosures

a. Install flush mounted luminaires to eliminate light leakage.

b. For luminaires mounted adjacent to insulation, provide barrier to prevent insulation from coming in contact with luminaire, unless luminaire is approved for installation in contact with such insulation.

c. Provide approved fire rated enclosures around luminaires in fire rated ceilings.

6. Conduit and Wiring

a. Wire for connections to lamp sockets and auxiliaries shall be suitable for temperature, current, and voltage conditions.

b. Recessed luminaires shall have final connections made with flexible metal conduit, not in excess of 72", with THHN conductors and green wire ground conductor.

c. Conduit shall be hidden from normal view in all possible cases. In public areas where surface mounted conduit must be used, contractor shall install conduit as unobtrusively as possible. Contractor shall obtain field approval by the architect for all exposed conduit runs prior to rough in.

7. Cast-in Luminaires:

a. Where installed in tree grates, furnish burial light lens and louver to tree grate manufacturer for coordination of opening.

b. Provide adequate drainage system per manufacturer's recommendations.

C. Installation of Outdoor Pole Bases

1. General Contractor shall provide bases for luminaires.

2. Electrical Contractor shall:

a. Rough-in conduits

b. Furnish information to General Contractor for spacing, base dimensions, heights, orientation of bases, etc.

3. Where square or rectangular poles or luminaire heads are used, Contractor shall verify orientation with Architect.

D. Pole Installation:

1. Install luminaires, poles, hardware, etc., for complete system.

2. Use web fabric slings (not chain or cable) to raise and set poles.

E. Lamps:

1. Provide new lamps delivered in original manufacturer’s cartons.
2. Fluorescent and metal halide lamps shall be energized continuously for not less than 100 hours for proper seasoning.

F. Grounding:
1. Ground luminaires and metal poles according to Division 26 Section "Grounding and Bonding for Electrical Systems".
2. Poles:
   a. Install 10 ft driven ground rod at each pole.
3. Nonmetalic Poles:
   a. Ground metallic components of lighting unit and foundations. Connect luminaires to grounding system with No. 10 AWG conductor.

G. Spare Parts:
1. Provide 5% spare lamps for each type in Luminaire Schedule
   a. Spare lamps shall be delivered to Laboratory in new condition and in original packaging.
   b. Manufacturer and model number shall match those installed in the project's luminaires.
2. Provide spare ballasts, 1 for every 100 of each type and rating installed. Furnish at least one of each type.
3. Provide spare globes and guards, 1 for every 20 of each type and rating installed. Furnish at least one of each type.
4. Provide spare parabolic louvers and reflector cones, 1 for every 100 of each type. Furnish at least one of each type.
5. Provide spare plastic diffusers and lenses, 1 for every 100 of each type and rating installed. Furnish at least one of each type.

3.2 SUBSTANTIAL COMPLETION

A. Quality Control:
1. At Date of Substantial Completion, replace lamps which are not operating properly.
2. Replace any lamps used as worklights during construction phase.
3. Protection wrapping on louvered (parabolic) luminaires shall be removed before installation of furniture, but after finish work is complete.
4. Deliver spare lamps to Laboratory's representative.

B. Tests:
1. Give advance notice of dates and times for field tests.
2. Provide instruments to make and record test results.
3. Verify normal operation of each luminaire after luminaires have been installed and circuits have been energized.
4. Replace or repair malfunctioning luminaires and components, then retest. Repeat procedure until all units operate properly.
5. Report results of tests.

C. Adjusting and Cleaning:
1. Clean luminaires of handling marks, dust and dirt.
2. Cleaning and touch-up work shall be performed in accordance with luminaire manufacturer's recommendations.
3. Damaged luminaires or components shall be replaced with new.

4. Keep luminaires clean and protected for remainder of construction period.
5. Verify orientation of directional luminaires prior to installation.
   a. This includes wall washers, cove lighting, floodlights, exterior area lights and adjustable accent luminaires. Contractor shall provide electrician's services to aim, adjust, and focus luminaires, as required, at the direction of Architect/Engineer. These electricians shall be available at times designated by the Architect/Engineer and shall be provided at no extra charge to the Laboratory over base bid. Contractor shall provide equipment for luminaries' focus including ladders and mechanical lifting systems.
6. Program preset dimming system lighting levels.
7. Exterior poles, bollards, bases and other exterior luminaires shall be painted to match factory color where finish has been damaged.
8. No light leaks shall be permitted at the ceiling line from any visible part or joint.

D. Training
1. Contractor shall provide qualified personnel onsite to provide a minimum of three days of training to Laboratory's representatives.
2. This training shall cover:
   a. Luminaire use and maintenance
   b. Architectural lighting system use and maintenance
   c. Group relamping cycles

E. STARTUP
1. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

F. FUNCTIONAL PERFORMANCE TESTS
1. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

End of Section

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SECTION 26 90 00

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description

B. Responsibilities

C. Related Work

D. Test Equipment

E. Submittals

F. Startup

G. Contractor Tests

H. Functional Performance Tests

I. Testing Documentation, Non-Conformance and Approvals

J. Operation and Maintenance Manuals

K. Training of Owner Personnel

L. Deferred Testing

M. Written Work Products

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 26 responsibilities in the commissioning process that are being directed by the CxA. Other electrical systems testing are required under the direction of the GC.

B. The list of commissioned equipment and systems is found in Section 01 91 00.

C. Commissioning requires the participation of Division 26 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 26 shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CxA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.3 RESPONSIBILITIES

A. Electrical Contractors. The commissioning responsibilities applicable to the Electrical Contractor are as follows *(all references apply to commissioned equipment only)*:

1. Construction and Acceptance Phases:

   a. Include the cost of commissioning in the contract price.

b. In each purchase order or subcontract written, include requirements for submittal data, O&M data and training.

c. Attend a commissioning scoping meeting and other necessary meetings scheduled by the CxA to facilitate the Cx process.

d. Contractors shall provide normal cut sheets and shop drawing submittals to the CxA of commissioned equipment.

e. Provide additional requested documentation, prior to normal O&M manual submittals, to the CxA for development of start-up and functional testing procedures.

1) Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any Owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.
2) The Commissioning Agent may request further documentation necessary for the commissioning process.
3) This data request may be made prior to normal submittals.

f. Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CxA for review and approval.

g. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

h. Provide assistance to the CxA in preparation of the specific functional performance test procedures. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.

i. Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists from the CxA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CxA for review.

j. During the startup and initial checkout process, execute and document the electrical-related portions of the prefunctional checklists provided by the CxA for all commissioned equipment.

k. Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CxA.

l. Address current A/E punch list items before functional testing.

m. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.

n. Perform functional performance testing under the direction of the CxA for specified equipment in Section 01 91 00. Assist the CxA in interpreting the monitoring data, as necessary.

o. Correct deficiencies (differences between specified and observed performance) as interpreted by the CxA, GC and A/E and retest the equipment.

p. Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.

q. During construction, maintain as-built red-line drawings for all drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line as-built drawings for all drawings and final as-builts for Contractor-generated coordination drawings.

r. Provide training of the Owner's operating personnel as specified.

s. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Warranty Period

a. Execute seasonal or deferred functional performance testing, witnessed by the CxA, according to the specifications.

b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

1.4 RELATED WORK

A. Refer to Section 01 91 00 for a listing of all sections where commissioning requirements are found.

B. Refer to Section 01 91 00 for systems to be commissioned.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Division 26 shall provide all test equipment necessary to fulfill the testing requirements of this Division.

B. Refer to Section 01 91 00 for additional Division 26 requirements.

PART 3 - EXECUTION

3.1 SUBMITTALS

A. Division 26 shall provide submittal documentation relative to commissioning to the CxA as requested by the CxA. Refer to Section 01 91 00 for additional Division 26 requirements.

3.2 STARTUP

A. The Electrical Contractor shall follow the start-up and initial checkout procedures listed in the Responsibilities List in this section and in Section 01 91 00. Division 26 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.

B. Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems, or sub-systems at the discretion of the CxA. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.3 CONTRACTOR TESTS

A. Subcontractors/installers shall forward to the Commissioning Authority, through the GC, a list and schedule of specified contractor tests. The tests shall include at least the following:

Section 26 05 73	OCP Coordination Study	Coordination Study Arc Flash Study
Section 26 08 12	Power Distribution Acceptance Tests	Tests of Commissioned Electrical Equipment
Section 26 09 13	Power Monitoring and Control	Test Reports
Section 26 23 00	Low Voltage Switchgear	Test Reports
Section 26 36 23	Automatic Transfer Switches	Factory Tests

B. Unless specified otherwise, provide a minimum one week prior notice to the Commissioning Authority and A/E, through the GC for each specified Contractors' test.

C. Submit Contractors' test reports to the Commissioning Authority and A/E, through the GC within one week of the successful completion of each test. Contractors shall document and issue a test report for each required test. The test report shall contain all information required by the respective specification section including the test date, start time, stop time, test duration, initial values, final values, expected result, and acceptable test values (per individual specification sections). The person(s) conducting each test and the local code authority (if applicable) shall sign and date each test report indicating that the test has been successfully completed and the results are within acceptable parameters.

3.4 FUNCTIONAL PERFORMANCE TESTS

A. Refer to Section 01 91 00 for a list of systems to be commissioned. Samples are included at the end of this section for representative test formats and examples.

3.5 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

A. Refer to Section 01 91 00 for specific details on non-conformance issues relating to prefunctional checklists and tests.

B. Refer to Section 01 91 00 for issues relating to functional performance tests.

3.6 OPERATIONS AND MAINTENANCE (O&M) MANUALS

A. Division 26 shall compile and prepare documentation for all equipment and systems covered in Division 26 and deliver to the GC for inclusion in the O&M manuals, according to Section 01 70 00.

B. The CxA shall receive a copy of the O&M manuals for review.

3.7 TRAINING OF OWNER PERSONNEL

A. The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.

B. The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment or systems. Refer to Section 01 70 00 for additional details.

C. Electrical Contractor. The Electrical Contractor shall have the following training responsibilities:

1. Provide the CxA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00.
2. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of each major piece of commissioned electrical equipment or system.

3. Training shall start with classroom sessions, if necessary, followed by hands-on training on each piece of equipment that shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
5. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.
6. The training sessions shall follow the outline in the table of contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
7. Training shall include:
   a. Use the printed installation, operation and maintenance instruction material included in the O&M manuals.
   b. Include a review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
   c. Discuss relevant health and safety issues and concerns.
   d. Discuss warranties and guarantees.
   e. Cover common troubleshooting problems and solutions.
   f. Explain information included in the O&M manuals and the location of all plans and manuals in the facility.
   g. Discuss any peculiarities of equipment installation or operation.
   h. Classroom sessions shall include the use of overhead projections, slides, video and audio taped material as might be appropriate.
8. Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and maintenance of all pieces of equipment.
9. The Electrical Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not *controlled* by the central control system.
10. Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

3.8 DEFERRED TESTING

A. Refer to Section 01 91 00 for requirements of deferred testing.

3.9 WRITTEN WORK PRODUCTS

A. Written work products of Contractors will consist of the startup and initial checkout plan described in Section 01 91 00 and the filled out startup, initial checkout and prefunctional checklists.

End of Section

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SECTION 27 00 00

GENERAL COMMUNICATIONS REQUIREMENTS

PART 1 - GENERAL

1.1 SCOPE

A. This section details references, standards, guidelines, requirements and conditions common to all Division 27 work.

B. Work under this Section and related sections is subject to requirements of Contract Documents including General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

1.2 DESCRIPTION

A. Intent of drawings and specifications is to obtain complete systems tested, adjusted, and ready for operation.

B. Except as otherwise defined in greater detail, terms "provide", "furnish" and "install" as used in Division 27 contract documents shall have the following meanings:

1. "Provide" or "provided" shall mean "furnish and install".
2. "Furnish" or "furnished" does not include installation.
3. "Install" or "installed" does not include furnishing.

C. Include incidental details not usually shown or specified, but necessary for proper installation and operation.

D. Check, verify and coordinate work with drawings and specifications prepared for other trades. Include modifications, relocations or adjustments necessary to complete work or to avoid interference with other trades.

E. Included in this contract are connections to equipment provided by others. Refer to Architectural, Electrical, Integrated Automation, Mechanical, Security and final shop drawings for equipment being furnished under other sections for exact locations of outlets and various connections required.

F. Information given herein and on drawings is as exact as could be secured but is not guaranteed. Do not scale drawings for exact dimensions.

G. Where architectural features govern location of work, refer to architectural drawings.

H. All work shall be performed in "neat and workmanlike" manner as defined in ANSI/NECA 1 "Standard Practices for Good Workmanship in Electrical Contracting".

1.3 RELATED WORK

A. Related Division 27 Sections include:

1. Section 27 0526 - Grounding and Bonding for Communications Systems
2. Section 27 0528.29 - Hangers and Supports for Communications Systems
3. Section 27 0528.33 - Raceway and Boxes for Communications Systems
4. Section 27 0528.36 - Cable Tray for Communications Systems
5. Section 27 0528.39 - Surface Raceways for Communications Systems
6. Section 27 0553 - Communications Systems Identification
7. Section 27 1000 - Structured Cabling

8. Section 27 1100 - Communications Equipment Room Fittings
9. Section 27 1300 - Communications Backbone Cabling
10. Section 27 1500 - Communications Horizontal Cabling
11. Section 27 1600 - Communication Connecting Cords, Devices and Adapters

B. Related sections in other Divisions of Work:
1. Section 26 0593 – Electrical Systems Firestopping
2. Also see individual technical sections identified above.

C. Painting:
1. Furnish equipment with factory applied prime finish unless otherwise specified.
2. If factory finish on equipment furnished by Contractor is damaged in shipment or during construction, refinish equipment to satisfaction of Engineer.
3. Furnish one can of touch up paint for each factory finish, which will be final finished surface of product.
4. Contractor is responsible for painting of plywood in Telecommunications Equipment Rooms. Refer to Drawings.

1.4 REQUIREMENTS OF REGULATORY AGENCIES

A. Rules and regulations of Federal, State and local authorities and utility companies, in force at time of execution of contract shall become part of this specification.

1.5 REFERENCES AND STANDARDS

A. Design, cable and component selection, and installation practices shall conform with following:
1. ANSI/NFPA 70 - National Electrical Code
2. Local Electrical Code
3. Country, state and local health, safety and building codes
4. UL 444 - Communications Cables
5. Standards identified in individual Technical Sections.
6. The Network & Communication System Cabling System Specifications for New Buildings, and Building Rehabilitations

B. Agencies or publications referenced herein refer to the following:
1. ANSI American National Standards Institute
2. ASME American Society of Mechanical Engineers
3. ASTM American Society for Testing and Materials
4. BICSI Building Industry Consulting Services International
5. EIA Electronic Industries Alliance
6. FIPS Federal Information Processing Standards
7. FCC Federal Communications Commission
8. ICEA Insulated Cable Engineers Association
9. IEEE Institute of Electrical and Electronics Engineers
10. NEC National Electrical Code
11. NECA National Electrical Contractors Association
12. NEMA National Electrical Manufacturers Association
13. NESC National Electrical Safety Code
14. NETA National Electrical Testing Association

15. NFPA National Fire Protection Association
16. NIST National Institute of Standards and Technology
17. OSHA Occupational Safety and Health Administration
18. TIA Telecommunications Industry Association
19. UL Underwriters Laboratories, Inc.

C. Work shall be in accordance with latest edition of codes, standards or specifications unless noted otherwise.

1.6 DEFINITIONS

A. The following definitions are applicable to communications environments and shall apply to this document and its companion sections for clarification and direction.

1. Entrance facility - an entrance to building for both public and private network service cables and/or wireless services including entrance point of building and continuing to Entrance Room.
2. Entrance Room - room where both public and private network service cables and/or wireless services are terminated. Service provider(s) point-of-demarcation (DEMARC) is typically located here.
3. Equipment Room (Telecom) - an environmentally controlled centralized space for telecommunications equipment that usually houses main or intermediate cross-connect. Backbone cabling, cabling to Building Entrance and horizontal cabling may be terminated here.
4. Guarantee - promise or an assurance that attests to quality or durability of product or service or that task will be performed in specified manner. Used interchangeably with "Warranty" in these documents.
5. Intra-building - within single building.
6. Inter-building - between 2 or more buildings.
7. IP Telephony - Use of Internet Protocol (IP) for two-way transmission of conversations. Sometimes referred to as “Voice over Internet Protocol (VoIP)”.
8. Rack Unit - standard measurement of vertical mounting space on an equipment rack. Each Rack Unit is 1.75" high.
9. Voice over Internet Protocol – See IP Telephony.

B. Typical NEMA Enclosures and Usage

1. Refer to Section 26 0000 – General Electrical Requirements.
1. NEMA 1 - Indoors. Falling dirt
2. NEMA 2 - Indoors. Falling dirt. Falling liquids. Light splashing
3. NEMA 3 - Outdoors. Sleet, snow, rain. Windblown dust
4. NEMA 3X - Same as NEMA 3 plus corrosion resistant
5. NEMA 3S - Same as NEMA 3 plus mechanism operable when ice covered
6. NEMA 3SX - Same as NEMA 3S plus corrosion resistant
7. NEMA 3R - Outdoors. Rain, snow, sleet
8. NEMA 3RX - Same as NEMA 3R plus corrosion resistant
9. NEMA 4:
   a. Indoors - Falling dirt. Falling and light splashing liquids. Flying dust, lint and fibers. Hose down
   b. Outdoors - Rain, sleet, snow. Wind blown dust. Hose down
10. NEMA 4X - Same as NEMA 4 plus corrosion resistant
11. NEMA 5 - Indoors. Falling Dirt. Falling Liquids. Settling dust, lint and fibers
12. NEMA 6:
    a. Indoors - Falling dirt. Falling and light splashing liquids. Flying dust, lint and fibers. Hose down. Temporary submersion.

b. Outdoors - Rain, snow, sleet. Windblown dust. Hose down. Temporary submersion.

13. NEMA 6P:
    a. Indoors - Same as NEMA 6 / Indoors plus corrosion resistant. Prolonged submersion.
    b. Outdoors - NEMA 6 /Outdoors plus corrosion resistant. Prolonged Submersion.
14. NEMA 7 - Indoors. Class I, Division 1 or 2, Groups A, B, C or D. (Flammable gas).
15. NEMA 9 - Indoors. Class II, Division 1 or 2. Groups E, R, or G. (Combustible dust).
16. NEMA 12 - Indoors. Falling Dirt. Falling liquids. Flying dust, lint and fibers. Oil or coolant seepage.
17. NEMA 13 - Same as NEMA 12 plus oil or coolant spraying or splashing.]

1.7 ABBREVIATIONS AND ACRONYMS

A. The following abbreviations and acronyms shall apply to this document and its companion sections for clarification and direction.

1. AFF Above Finished Floor
2. ATM Asynchronous Transfer Mode
3. AWG American Wire Gauge
4. BAS Building Automation Systems
5. BTU British Thermal Unit
6. CATV Community Antenna Television
7. CCTV Closed-Circuit Television
8. CDDI Copper Distributed Data Interface (Cisco Systems trade name for TP-PMD)
9. cm centimeters
10. °C degrees Celsius
11. °F degrees Fahrenheit
12. DTMF Dual Tone Multi Frequency
13. EIA Electronic Industries Alliance
14. EF Entrance Facility
15. ER Entrance Room
16. EIDF Equipment Intermediate Distribution Facility
17. FDDI Fiber Distributed Data Interface
18. ft feet
19. GbE Gigabit Ethernet
20. Hz Frequency in Hertz (k = kilo, M = Mega, G = Giga)
21. ID Inside Diameter
22. in inch
23. IPT IP Telephony
24. kg kilogram
25. lbs pounds
26. LAN Local Area Network
27. MATV Master Antenna Television
28. MC Main Cross-connect
29. m meters
30. mm millimeters
31. Mbps Megabits per second

32. µm micrometer (10^{-6} meter)
33. OD Outside Diameter
34. PBX Private Branch Exchange (Telephone Switch)
35. pF pico-Farad (10^{-12} Farad)
36. PVC Polyvinyl Chloride
37. RU Rack Unit
38. sq ft square feet (area)
39. TP-PMD Twisted Pair Physical Layer Medium
40. WAN Wide Area Network
41. WLAN Wireless Local Area Network
42. VoIP Voice over Internet Protocol

B. Refer also to technical sections for additional terminology.

1.8 LISTING

A. Refer to technical sections of this Division of work for listing requirements.

1.9 SUBMITTALS

A. Submit shop drawings for equipment provided under this Section:
   1. Refer to Division 1 - Submittal Procedures.
   2. Note that for satisfying submittal requirements for Division 27, "Product Data" is usually more appropriate than true "Shop Drawings" as defined in Division 1. However, expression "Shop Drawings" is generally used throughout specification.
   3. Mark catalog sheets and drawings to indicate specific items submitted.
      a. Markings shall be reproducible (arrow, boxed, encircled, checkmark, etc.).
      b. Where sheet includes multiple product options, mark proposed option(s).
   4. Include proper identification of equipment by name and/or number, as indicated in specification and shown on drawings.
   5. When manufacturer's reference numbers are different from those specified, provide correct cross-reference number for each item. Mark and annotate submittals clearly accordingly.
   6. Group submittals by Section to include complete documentation of related systems, products and accessories. Where applicable, dimensions shall be marked in units to match those specified.
   7. Submittals shall be in electronic form or on paper per Division 1.
      a. Documents in electronic form shall be ADOBE *Acrobat* PDF.
      b. Paper documents shall be original catalog sheets or photocopies thereof.
      c. Facsimile (fax) sheets will not be accepted.
   8. Engineer’s Review is to confirm compliance with performance, interoperability, physical, and other pertinent requirements of project. Review is not to confirm quantities nor that all required items have been submitted.
   9. When equipment and items specified include accessories, parts and additional items under one designation, submittals shall be complete and include required components.
   10. Include wiring diagrams for electrically powered or controlled equipment.
   11. Submit equipment room layouts drawn to scale, including equipment, raceways, accessories and clearance for maintenance.

12. Where submittals cover products containing potentially hazardous non-metallic materials, include "Material Safety Data Sheet" (MSDS) from manufacturer stating physical and chemical properties of components and precautionary considerations required.
13. Submit shop drawings or product data as soon as practicable after signing contracts. Submittals must be approved before installation of materials and equipment.
14. Submittals, which are not complete, not permanent, or not properly checked by Contractor, will be returned without review.
15. "Coordination Drawings", which are normally prepared by Contractor to coordinate work among various trades and to facilitate installation, shall not be submitted for Division 27 work unless specifically requested in technical sections. These types of drawings typically include dimensioned piping, ductwork, communications and/or electrical raceway layouts.
    a. Unless specifically requested in Division 27 technical sections, submittals of coordination drawings will be returned without review.

B. Certificates and Inspections:
1. Obtain and pay for inspections required by authorities having jurisdiction and deliver certificates approving installations to Laboratory unless otherwise directed.

C. Operation and Maintenance Manuals:
1. Refer to Division 1 - Closeout Procedures.
2. Upon completion of work but before final acceptance of system, submit to Architect for approval, 3 copies of operation and maintenance manuals in loose-leaf binders. If "one copy" is larger than 2" thick or consists of multiple volumes, submit only one set initially for review. After securing approval, submit 3 copies to Laboratory.
3. Manuals shall be organized by specification section number and shall have table of contents and tabs for each piece of equipment or system.
4. Manuals shall include the following:
    a. Copies of shop drawings.
    b. Manufacturer's operating and maintenance instructions. Include parts lists of items or equipment. Where manufacturer's data includes several types or models, applicable type or model shall be designated.
    c. CD ROM's of O&M data with exploded parts lists where available.
    d. Phone numbers and addresses of local parts suppliers and service companies.
    e. Internet/WEB page addresses where applicable.
    f. Wiring diagrams.
    g. Start up and shut down procedure.
    h. Factory and field test records.
    i. Additional information, diagrams or explanations as designated under respective equipment or systems specification section.
5. Instruct Laboratory's representative in operation and maintenance of equipment. Instruction shall include complete operating cycle on all apparatus.
6. O&M manuals and instructions to Laboratory shall be provided prior to request for final payment.

D. Record Documents:
1. Refer to General Conditions of Contract, and Division 1 - Closeout Procedures. Prepare complete set of record drawings in accordance with Division 1.

1.10 JOB CONDITIONS

A. Building Access:
   1. Arrange for necessary openings in building to allow for admittance of all apparatus.

B. Cutting and Patching:
   1. Refer to General Conditions of Contract, and Division 1 - Cutting and Patching.
   2. Perform cutting and patching required for complete installation of systems unless otherwise noted. Patch and restore work cut or damaged, to original condition. This includes openings remaining from removal or relocation of existing system components.
   3. Provide materials required for patching unless otherwise noted.
   4. Do not pierce beams or columns without permission of Architect and then only as directed. If openings are required through walls or floors where no sleeve has been provided, hole shall be core drilled to avoid unnecessary damage and structural weakening.
   5. Where alterations disturb lawns, paving, walks, etc., replace, repair or refinish surfaces to condition existing prior to commencement of work. This may include areas beyond construction limits.

C. Housekeeping and Cleanup:
   1. Refer to Division 1 - Closeout Procedures.
   2. Periodically as work progresses and/or as directed by Architect, remove waste materials from building and leave area of work broom clean. Upon completion of work, remove tools, scaffolding, broken and waste materials, etc. from site.

1.11 WORK BY LABORATORY

A. Laboratory will provide:
   1. Active electronics for interface with building voice and data cabling systems
   2. Connections from telephone and data equipment to Contractor provided cabling.
   3. Connections from Backbone Voice Cables to Horizontal Voice Cables.

1.12 QUALITY ASSURANCE

A. Refer to the individual technical sections for general product quality requirements, manufacturer qualifications, and contractor qualifications and certification requirements.

1.13 GUARANTEE

A. Refer to Division 1 for general Guarantee (Warranty) requirements.

B. Refer to technical sections for Guarantee requirement for each system.
   1. Where no guarantee requirements are called out, guarantee as called out in Division 1 equipment, materials, and workmanship to be free from defect.

C. Repair, replace or alter systems or parts of systems found defective at no extra cost to Laboratory.

D. Wherein fulfilling requirements of any guarantee, if Contractor disturbs any work guaranteed under another contract, restore such disturbed work to condition satisfactory to Architect and guarantee such restored work to same extent as it was guaranteed under such other contract.

E. Guarantees shall include labor, material and travel time.

PART 2 - PRODUCTS

2.1 PRODUCT SUBSTITUTIONS

A. Refer to Division 1 - Product Requirements.

PART 3 - EXECUTION

3.1 GENERAL

A. Verify elevations and measurements prior to installation of materials.

3.2 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Division 1.

B. Store and protect products under provisions of Division 1

C. Store in clean, dry space.

D. Maintain factory wrapping or provide cover to protect units from dirt, water, construction debris, and traffic.

E. Handle in accordance with manufacturer's written instructions.

F. Handle carefully to avoid damage to components, enclosure, and finish. Lift only with lugs provided for the purpose.

3.3 FLOOR, WALL, ROOF AND CEILING OPENINGS

A. Coordinate location of openings, chases, furred spaces, etc. with appropriate Contractors. Provide during progress of construction sleeves and inserts that are to be built into structure.

B. Temporary sleeves, if used to form wall openings, shall be removed prior to installation of permanent materials. Permanent sleeves for wall penetrations shall be minimum 24 ga galvanized sheet metal unless otherwise noted

C. Steel sleeves, when required, shall be Schedule 40 carbon steel pipe with integral water stop.

D. For core drilled holes, size and location shall be reviewed and approved by Structural Engineer prior to execution.

E. Submit product data and installation details for penetrations of building structure. Submittal shall include schedule indicating penetrating materials, (including steel conduit, PVC conduit, cables, cable tray), sizes of each, opening sizes and sealant products intended for use.

F. Where penetrations of fire-rated assemblies are involved, seal penetrations with appropriate firestopping systems as specified in Division 26.

G. Openings for penetrations shall be minimum 1/2" larger on all sides than outside dimensions of raceways or cables. However, where fire resistant penetrations are required, size openings in accordance with recommendations of firestopping systems manufacturer.

H. Seal non fire-rated floor penetrations with non-shrink grout equal to Embeco by Master Builders, or urethane caulk, as appropriate.

I. Seal non-rated wall openings with urethane caulk.

J. Where penetrations occur through exterior walls into building spaces, use steel sleeves with integral water stop, similar to type "WS" wall sleeves by Thunderline Corporation. Seal annular space between sleeves and pipe with "Link-Seal" modular wall and casing seals by Thunderline Corporation, or sealing system by another manufacturer approved as equal by Architect. Sealing system shall utilize Type 316 stainless steel bolts, washers and nuts.

K. Finish and trim penetrations as shown on details and as specified hereinafter.

L. Provide chrome or nickel plated escutcheons where raceways pass through walls, floors or ceilings and are exposed in finished areas. Size escutcheons to fit raceways for finished appearance. Finished areas shall not include mechanical/electrical rooms, janitor's closets, storage rooms, etc., unless suspended ceilings are specified.

3.4 EQUIPMENT ACCESS

A. Install raceways, junction and pull boxes, and accessories to permit access to equipment for maintenance. Relocation of raceways, or accessories as required to provide access, shall be provided at no additional cost to Laboratory.

B. Install equipment with ample space allowed for removal, repair or changes to equipment. Provide ready accessibility to equipment and wiring without moving other equipment, which is to be installed or which is already in place.

C. Access doors in walls, chases, or inaccessible ceilings will be provided under Division 8 - Access Doors and Frames, unless otherwise indicated. Access doors shall be for purpose of providing access where equipment requiring servicing, repairs or maintenance is located in walls, chases or above inaccessible ceilings.

D. Provide necessary coordination and information to Trade Contractor under Division 8 - Access Doors and Frames. This information shall include required locations, sizes and rough-in dimensions, without limitations.

E. Locate communications outlets and equipment to fit details, panels, decorating or finish at space. Architect reserves right to make minor position changes of outlet locations before work has been installed.

F. Verify room door swings before installing wall-mounted communications outlets and install boxes on latch side of door unless otherwise noted

3.5 EQUIPMENT SUPPORTS

A. Provide supporting steel not indicated on drawings as required for installation of equipment and materials including angles, channels, beams, hangers.

B. Concrete anchors, used for attachment to concrete, shall be steel shell with plug type. Plastic, rawhide or anchors utilizing lead are not allowed.

C. Do not support equipment or cable pathways from metal roof decking.

3.6 SUPPORT PROTECTION

A. In occupied areas, mechanical rooms and areas requiring normal maintenance access, certain equipment must be guarded to protect personnel from injury.

B. Provide minimum 1/2" thick Armstrong Armaflex insulation or similar product applied with Armstrong 520 adhesive on lower edges of equipment, including bus duct, cable tray, pull boxes and electrical supporting devices suspended less than 7 ft above floors, platforms or catwalks in these areas.

C. Threaded rod or bolts shall not extend beyond supporting element and shall be protected as described above.

3.7 HOUSEKEEPING PADS

A. Not applicable to this Division of work.

3.8 LEAD SHIELDING

A. Wherever installation of this Contractor's equipment destroys radiological integrity of wall, floor, or ceiling, this Contractor shall be responsible to provide suitable lead shielding to maintain that integrity. Coordinate these requirements with General Contractor.

3.9 ACCEPTANCE TESTING

A. Prior to testing, submit to Laboratory (or Laboratory's representative) and Engineer, proposed schedule for acceptance testing.
   1. This notification shall be minimum of 10 working days in advance to allow for participation by Laboratory and/or Engineer.

B. Prior to testing, submit written description of intended test procedures and submit sample test forms to Engineer.
   1. Submitted information shall include proposed file naming format to be used in identifying cable, pair or optical fiber which is subject of test record.
   2. Failure to provide above information shall be grounds for Engineer or Laboratory to reject any Documentation of related testing and to require repeat of affected test.

C. Conduct tests during course of construction when identifiable portion(s) of installation is complete.
   1. Alternatively, testing can be conducted after entire installation is complete if this does not delay project schedule.

D. Provide equipment and personnel necessary to conduct acceptance tests.

E. Testing shall be completed and accepted by Laboratory and Engineer before Laboratory furnished equipment and cross connects are installed.

F. Document tests.

G. When equipment or systems fail to meet minimum test requirements, replace or repair defective work or materials as necessary and repeat inspection and test. This shall be at no additional cost to the Laboratory. Replacement materials shall be new.

H. This Contractor is responsible for certifying, in writing, equipment and system test results. Certification shall include identification of portion of system tested, date, time, test criteria and name and title of person signing test certification documents.

I. Maintain copies of certified test results, including those for failed tests, at project site. At completion of project, include copies of test records and certifications in O&M Manuals.

3.10 START-UP

A. All systems and equipment shall be started, tested, adjusted and turned over to Laboratory ready for operation.
   1. This includes "Laboratory-Furnished, Contractor-Installed" (OFCI) and "Contractor-Furnished, Contractor-Installed" (CFCI) systems and equipment.

B. Follow manufacturer's pre-start-up checkout, start-up, trouble shooting and adjustment procedures.

C. Contractor shall provide services of technician/installer knowledgeable in start-up and checkout of types of systems and equipment on project.

D. Provide start-up services, by manufacturer's representative where specified or where Contractor does not have qualified personnel.

E. Coordinate start-up with trades.

3.11 DOCUMENTATION

A. Upon completion of installation, Contractor shall provide System Documentation. Documentation shall include:
   1. Acceptance Test Results
   2. Record Drawings
   3. All Approved Submittals
   4. Manufacturer’s Warranty Documents

B. Submit System Documentation in accordance with Division 1 "Project Record Documents".

C. Submit documentation within ten (10) working days of the completion of testing of each testing phase (e.g. subsystem, cable type, area, floor, etc.) or 3 weeks prior to scheduled occupancy of subject area, whichever is sooner. This is inclusive of Test Result and draft Record Drawings.
   1. Draft drawings may include mark-ups done by hand.
   2. Machine generated (final) copies of Record Drawings shall be submitted within 30 working days of completion of each testing phase.

D. Submit Acceptance Test Results in electronic form for review and distribution.
   1. Interim documentation of Test Results (if applicable) may be submitted via email or on CD-ROM.
   2. Final documentation of Test Results shall be submitted on CD-ROM.
   3. Test results shall be submitted in format(s) native to test instrument(s) used in performing testing.
   4. Where unique software (other than an MS-Word™ compatible Word Processor or MS-Excel™ spreadsheet) is required for viewing of test results, Contractor shall provide along with above documentation, one (1) licensed copy of such software. Software shall run on MICROSOFT Windows-based personal computer.

E. Acceptance Test results shall include description of sub-system tested, equipment/cable/outlet I.D., reference and test setup, test equipment type/model and serial number(s), equipment location and direction of test (if applicable), test frequencies/wavelengths, date and operator name(s).

F. Engineer or Laboratory may request that 10% random re-test be conducted on cable system - at no additional cost - to verify documented findings. Tests shall be a repeat of those defined above and in technical sections.
   1. Laboratory may also perform independent testing to verify results.

2. If findings contradict documentation submitted by Contractor, additional testing can be requested to extent determined necessary by Engineer or Laboratory, including 100% re-test. This re-test shall be at no additional cost to Laboratory.

G. Documentation - including hard copy and electronic forms of Test Data and Record Drawings - shall become property of Laboratory.

H. Refer also to Technical Sections for requirements specific to covered subsystems.

3.12 CLEANING

A. After installation is complete, Contractor shall clean all systems.

B. Vacuum debris from system components, enclosures, junction boxes and pull boxes prior to testing and again prior to completion.

C. Thoroughly clean equipment of stains, paint spots, dirt and dust. Remove temporary labels not used for instruction or operation.

End of Section

SECTION 27 05 26

GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section includes product and execution requirements for Grounding and Bonding that are unique to communications systems and not included in Division 26 sections.

B. Refer to Section 26 0526 - Grounding and Bonding for Electrical Systems - Part 1 for References, Standards, Submittals, Quality Assurance, Delivery/Storage/Handling, and Guarantee.

1.2 RELATED WORK

A. Related Division 27 Sections include:
1. Section 27 00 00 - General Communications Requirements
2. Section 27 05 28.33 - Raceway and Boxes for Communications Systems
3. Section 27 05 28.36 - Cable Tray for Communications Systems
4. Section 27 05 28.39 - Surface Raceways for Communications Systems
5. Section 27 05 53 - Communications Systems Identification
6. Section 27 10 00 - Structured Cabling
7. Section 27 11 00 - Communications Equipment Room Fittings
8. Section 27 13 00 - Communications Backbone Cabling
9. Section 27 15 00 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
1. Section 26 0526 - Grounding and Bonding for Electrical Systems

PART 2 - PRODUCTS

2.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0526 - Grounding and Bonding for Electrical Systems - Part 2

PART 3 - EXECUTION

3.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0526 - Grounding and Bonding for Electrical Systems - Part 3

End of Section

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SECTION 27 05 28.29

HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. This section includes product and execution requirements for items unique to communications systems and not included in Division 26 sections.

B. Refer to Section 27 0000 – General Communications Requirements and 26 0529 - Hangers and Supports for Electrical Systems - Part 1 for requirements for Reference Standards, Submittals, Quality Assurance, Delivery/Storage/Handling, and Guarantee.

1.2 RELATED WORK

A. Related Division 27 Sections include:
1. Section 27 00 00 - General Communications Requirements
2. Section 27 05 28.33 - Raceway and Boxes for Communications Systems
3. Section 27 05 28.36 - Cable Tray for Communications Systems
4. Section 27 10 00 - Structured Cabling
5. Section 27 11 00 - Communications Equipment Room Fittings
6. Section 27 13 00 - Communications Backbone Cabling
7. Section 27 15 00 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
1. Section 26 0529 - Hangers and Supports for Electrical Systems

1.3 REFERENCES AND STANDARDS

A. The Work under this Section is subject to requirements of the Contract Document including the General Conditions, Supplementary Conditions, and section sunder Division 01 General Requirements.

PART 2 - PRODUCTS

2.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0529 - Hangers and Supports for Electrical Systems - Part 3 for:
1. Hanger Rods
2. Beam Clamps
3. Wall Anchors
4. Metal Framing

2.2 J-TYPE CABLE SUPPORT HOOKS

A. Cable support hooks shall be a wide-base type for use in a non-continuous pathway.

B. Hook material shall be Galvanized metal or Nylon for smooth cable pull and corrosion resistance.
1. Hook may be coated to reduce cable friction.

C. Hooks shall:
   1. Comply with UL, cUL, NEC and EIA/TIA requirements for structured cabling systems.
   2. Be designed to limit cable bending per cable manufacturers' recommendations.
   3. Be capable of being installed in a single- or multiple-hook ("tree") configuration.
   4. Incorporate a latch or other mechanism to retain cable.

PART 3 - EXECUTION

3.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0529 - Hangers and Supports for Electrical Systems - Part 3 for all products identified in Part 1.

3.2 J-TYPE CABLE SUPPORT HOOKS

A. Where installed free-air above suspended ceiling or below raised floor, support cables using J-hook type cable supports installed in accordance with manufacturer's installation requirements.

B. Support hooks from structure. Do not support from ceiling grid, conduit or other trades work.

C. Space J-hook cable supports every 4 ft or in accordance with cable manufacturer's specifications, whichever distance is shorter.

D. J-hook fill capacities shall be per manufacturer's recommendations and shall consider diameter of cable type(s) being installed.

End of Section

SECTION 27 05 28.33

RACEWAY AND BOXES FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. This section includes product and execution requirements for items unique to communications and not included in Division 26 sections.

1.2 DESCRIPTION

A. Refer to Section 26 0533 - Raceway and Boxes for Electrical Systems - Part 1 for requirements for Standards, Submittals, Quality Assurance, Delivery/Storage/Handling, and Guarantee for:
   1. Outlet Boxes
   2. Pull and Junction Boxes
   3. Raceways and Wireways (including sleeves, expansion fittings, penetrations and seals)
   4. Indoor Service Poles
   5. Poke-through Fittings
   6. Floor Boxes
   7. Cable Supports

1.3 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 00 00 - General Communications Requirements
   2. Section 27 05 26 - Grounding and Bonding for Communications Systems
   3. Section 27 05 28.29 - Hangers and Supports for Communications Systems
   4. Section 27 05 28.36 - Cable Tray for Communications Systems
   5. Section 27 05 28.39 - Surface Raceways for Communications Systems
   6. Section 27 05 53 - Communications Systems Identification
   7. Section 27 10 00 - Structured Cabling
   8. Section 27 11 00 - Communications Equipment Room Fittings
   9. Section 27 13 00 - Communications Backbone Cabling
   10. Section 27 15 00 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. Section 26 0533 - Raceway and Boxes for Electrical Systems

1.4 REFERENCES AND STANDARDS

A. The Work under this section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

PART 2 - PRODUCTS

2.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0533 - Raceway and Boxes for Electrical Systems - Part 2 for Outlet Boxes for Communications, Pull and Junctions Boxes for Communications, Raceways for Communications, and other products identified in Part 1.

2.2 COMMUNICATIONS RACEWAYS

A. OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY (INNERDUCT)
1. UL 2024; flexible type, approved for riser installation.
2. Outdoor Innerduct: Smooth outside and ribbed inside.
3. Indoor Innerduct: Corrugated.
4. Color:
a. Riser: Orange.
5. Manufacturers: Carlon; Pyramid.

PART 3 - EXECUTION

3.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0533 - Raceway and Boxes for Electrical Systems - Part 3 for Outlet Boxes for Communications, Pull and Junctions Boxes for Communications, Raceways for Communications, and other products identified in Part 1.

3.2 COMMUNICATIONS RACEWAYS

A. Optical Fiber Communications Cable Raceway (Innerduct):
1. Minimum innerduct size: 1”, unless otherwise noted on drawings.
2. Extend innerduct to termination and/or storage enclosure.
3. Install couplings designed for innerduct size and type where innerduct enters a termination and/or storage enclosure.
4. Splice innerduct segments using couplings designed for that purpose, where not installed in a continuous length.
5. Install 200 lb nylon pull cord in empty innerduct. Leave at least 12” of slack at each end of pull wire. Cap innerduct at both ends.
6. Label innerduct with tags indicating cable type and cables contained therein.
a. Label in each maintenance hole, pull box and communications equipment room, where exiting a conduit and at 35 ft intervals in cable tray or where otherwise exposed.

End of Section

SECTION 27 05 28.36

CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. This Section includes product and execution requirements for items unique to communications and not included in Division 26 Sections.

1.2 DESCRIPTION

A. Refer to Sections 27 0000 – General Communications Requirements and 26 0536 - Cable Trays for Electrical Systems- for Standards, Submittals, Delivery/Storage/Handling, and Guarantee for:
   1. Wire Mesh-type Tray.
   2. Splice Plates.
   3. Supports.
   4. Barriers.
   5. Tray Covers.
   6. Warning Signs.

1.3 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 00 00 - General Communications Requirements.
   2. Section 27 05 28.33 - Raceway and Boxes for Communications Systems.
   3. Section 26 05 29 - Hangers and Supports for Electrical Systems.
   4. Section 27 10 00 - Structured Cabling.
   5. Section 27 11 00 - Communications Equipment Room Fittings.
   6. Section 27 13 00 - Communications Backbone Cabling.
   7. Section 27 15 00 - Communications Horizontal Cabling.

B. Related sections in other Divisions of Work:
   1. Section 26 0536 - Cable Trays for Electrical Systems.

1.4 REFERENCES AND STANDARDS

A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and section sunder Division 01 General Requirements.

PART 2 - PRODUCTS

2.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0536 - Cable Trays for Electrical Systems - Part 2 for products identified in Part 1.

PART 3 - EXECUTION

3.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0536 - Cable Trays for Electrical Systems - Part 3 for products identified in Part 1.

End of Section

SECTION 27 05 28.39

SURFACE RACEWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section includes product and execution requirements for items unique to communications and not included in Division 26 Sections.

B. Refer to Section 26 0533.13 - Surface Raceway System - Part 1 for References, Standards, Submittals, Quality Assurance, Delivery/Storage/Handling, and Guarantee.

1.2 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 00 00 - General Communications Requirements.
   2. Section 27 10 00 - Structured Cabling.
   3. Section 27 13 00 - Communications Backbone Cabling.
   4. Section 27 15 00 - Communications Horizontal Cabling.

B. Related sections in other Divisions of Work:
   1. Section 26 0533.13 - Surface Raceway System.

PART 2 - PRODUCTS

2.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0533.13 - Surface Raceway System - Part 2.

PART 3 - EXECUTION

3.1 PRODUCTS COMMON WITH ELECTRICAL SYSTEMS

A. Refer to Section 26 0533.13 - Surface Raceway System - Part 3.

End Of Section

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SECTION 27 05 53

COMMUNICATIONS SYSTEMS IDENTIFICATION

PART 1 - GENERAL

1.1 SCOPE

A. This section details product and execution requirements for labeling of communications cabling, termination components, pathways and spaces for Communications Systems.

1.2 DESCRIPTION

A. All components shall be clearly labeled to identify them as unique throughout the project.

B. Labeling requirements include identification of Rooms, Equipment Racks, Telecommunications Outlets, Horizontal and Backbone Cabling, Termination Hardware (Patch Panels, Blocks) and Grounding.

1.3 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 00 00 - General Communications Requirements
   2. Section 27 05 26 - Grounding and Bonding for Communications Systems
   3. Section 27 10 00 - Structured Cabling
   4. Section 27 11 00 - Communications Equipment Room Fittings
   5. Section 27 13 00 - Communications Backbone Cabling
   6. Section 27 15 00 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. See individual technical sections identified above (if applicable).

1.4 REFERENCES AND STANDARDS

A. Refer to Section 27 0000 - General Communications Requirements which identifies pertinent References and Standards.

B. Other applicable references and standards include:
   1. TIA/EIA-606-A - Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.

1.5 DEFINITIONS

A. Refer to Section 27 00 00 - General Communications Requirements and Section 27 10 00 - Structured Cabling which provide information on Definitions used in this and related sections.

1.6 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 00 00 - General Communications Requirements and Section 27 10 00 - Structured Cabling which provide information on Abbreviations and Acronyms used in this and related sections.

1.7 WORK BY LABORATORY

A. Refer to Section 27 00 00 - General Communications Requirements which identifies Work by Laboratory affecting sub-system(s) covered by this section.

1.8 SUBMITTALS

A. Refer to Section 27 00 00 - General Communications Requirements and Section 27 10 00 - Structured Cabling which provide general guidelines for product and/or installation information to be submitted by contractor.

B. Prior to installation, provide samples of label types planned for the project.
   1. Samples shall include examples of lettering to be used and shall follow standards detailed below.

1.9 QUALITY ASSURANCE

A. Refer to Section 27 00 00 - General Communications Requirements which identifies general quality assurance requirements for the project.

PART 2 - PRODUCTS

2.1 GENERAL

A. Labels and markings shall be physically and chemically resistant to damage that would make label unreadable.

B. Cable labels shall be self-laminating, White/Transparent Vinyl and incorporate an integrated clear lamination which, when label is wrapped around cable, covers printed part of label.
   1. Labels shall be of adequate size to accommodate circumference of cable(s) being marked and properly self-laminate over full extent of printed area of label.
   2. Labels on larger cables (e.g. Copper Backbone) may be wrapped with clear non-removable tape.

PART 3 - EXECUTION

3.1 GENERAL

A. Labeling shall be by mechanical means.
   1. Hand lettered designations are not allowed.

B. Tags shall be non-removable.
   1. Exceptions:
      a. Telecommunications Outlet labels that are placed in recessed label holders.
      b. Telecommunications Ground tags secured with cable ties.
      c. Innerduct Tags secured with cable ties.

C. Characters shall be Black Ink and printed on background of contrasting color.

D. Labels shall match hardware layout and design.

E. Labels shall be as large as practicable while fitting properly.

F. No lettering shall be smaller than 10-point.

G. Label cables with tag which is wrapped around cable sheath.

3.2 ROOM IDENTIFICATION

A. Label Communications Backboard or Equipment Rack closest to entry door with unique identifying code.

B. Characters shall be 1-inch minimum.

C. Room ID shall be one numeric digit
   1. 0 shall be reserved for BDF

3.3 EQUIPMENT RACK IDENTIFICATION

A. Label each Equipment Rack with a unique alpha character starting at “A”

B. Position Labels at top of rack.

C. Characters shall be 1-inch minimum.

3.4 TELECOMMUNICATIONS OUTLET

A. Label each Telecommunications Outlet (TO) connector with unique identifying code.

B. Telecommunications Outlet connector numbering shall be based on - or result in - logical numbering sequence in work area.
   1. Labeling plans that results in random TO numbering in work area are not acceptable.

C. Place Faceplate labels on outside of cover.

D. Position Labels in recessed label holders on faceplate and covered with clear plastic covers.
   1. Where Communications Outlet Faceplates not incorporating recessed holders are allowed, faceplate labels shall be protected with clear laminate.

E. Telecommunications Outlet labeling code shall be as follows:
   1. TR.PXX.RMNO.##, where:
      a. “TR” is Identifier for room where cable terminates in horizontal cross-connect.
      b. “P” is Patch Panel on which cable is terminated at HC.
         1). Alpha character starting at “A”.
         2). Panel numbering shall be from Top (of Rack) to Bottom.
      c. “XX” is Port number in Patch Panel where cable terminates.
      d. "RMNO" is Room Number where TO resides.
      e. "##" is unique jack number per floor.
   2. Example: "M133.F12.L159.02” represents the 2nd jack in room “L159” terminating on the 12th port of patch panel “F” in Telecommunications Room “M133”.
      a. Faceplate labels can use common TR identifiers on each label strip. For example, two data jacks served from TR M133 sharing common label strip may be represented by:

M133	
F12.L159.02	F13.L159.03

3.5 HORIZONTAL CABLING

A. Label each horizontal cable at Telecommunications Outlet and at horizontal cross-connect with unique identifying code.

B. Cable shall be labeled at both ends within 4" of cable choke (end of jacket).

C. Horizontal labeling code shall be as follows:

1. CAT
   RMNO.##
   TR.##
   a. “CAT” is cable type.
   b. “RMNO” is Room Number where TO resides.
   c. “##” is unique jack number per floor.
   d. “TR” is Identifier for room where cable terminates in horizontal cross-connect.
   e. "##" is unique jack number per floor.
2. Example:

CAT 6A
L159.02
M133.02

3.6 MODULAR PATCH PANEL

A. Label each patch panel and port at horizontal cross-connect with unique identifying code.

B. Horizontal Patch panel labeling code shall be as follows:
   1. Label Panel I.D.
      a. Panel labeling shall be from Top to Bottom.
      b. Use alpha character (A-Z).
   2. Label Individual Port I.D.
      a. Port I.D. shall be from Left to Right, Top to Bottom.
      b. RMNO.##
         1). “RMNO” is Room Number where TO resides.
         2). “##” is unique jack number per floor.

C. Riser Patch panel labeling code shall be as follows:
   1. Label Panel I.D.
      a. Panel labeling shall be from Top to Bottom.
      b. Label shall include
         1). Frame Type (example: IDF)
         2). Frame Identification
            a). BLDX
            b). Where “BLD” is building identification and “X” is sequential alpha character.

D. Room number is not required on modular patch panels.

E. Equipment Rack number is not required on modular patch panels.

3.7 BACKBONE COPPER CABLE

A. Label each backbone cable at both ends at termination point with unique identifying code.

B. Label cable sheath:
   1. At point where sheath ends
   2. At point on cable where viewing of label is not obscured by termination blocks or other visual barrier.

C. Label shall be on plastic tag tie-wrapped to cable sheath, or placed on adhesive labels adhered to cable sheath.
   1. If adhesive labels are used, cable sheath shall be cleaned thoroughly before applying label. Clear cellophane tape covering shall be placed over label to protect it and maintain adhesion to sheath.

D. Label Intra-building cables with:
   1. Pair numbers
      a. Next series available per building
      b. Where multiple cables are installed between same end-points, labeling shall indicate sequential pair numbering.
         1). For example 400-pair provided as two 200-pair cables would be labeled "001-200" and "201-400".
   2. Cable size
      a. Actual cable size in pairs
   3. Feed from
      a. Location ID of far end frame
   4. Location where feed is from
      a. Building and Floor where feed is from
   5. Example 1200-pair cable from Building 221 service floor room 0:

0601 to 01199
01200
2210
Bldg 221 svc floor

3.8 TERMINATION BLOCKS

A. Termination Blocks shall be labeled with color-coded designation strips.

B. Label termination positions in horizontal row with position identifier.

C. Place termination block labels above or below termination.

D. Horizontal Cabling Blocks shall incorporate BLUE Designation Strips and shall identify:
   1. Telecommunications Outlet / Jack I.D.s

E. Intra-Building (within building) Backbone Cabling Blocks shall incorporate WHITE Designation Strips.
   1. Label Designation Strips with:
      a. Cable Origin & Destination
         1). Repeat on every designation strip.
      b. Pair Count.
         1). Label 1st and 25th Positions on each row (e.g. 001 & 025, 026 & 050, etc.).
   2. Example ER106 to TR3164:

001	ER106-TR3164	025
026	ER106-TR3164	050

3.9 BACKBONE FIBER OPTIC CABLING

A. Label each backbone cable at both ends at termination point with unique identifying code.

B. Label shall be placed on adhesive labels adhered to cable sheath.
   1. Cable sheath shall be cleaned thoroughly before applying label.

C. Label Intra-building cables with:
   1. Fiber numbers
      a. Next series available per building
      b. Where multiple cables are installed between same end-points, labeling shall indicate sequential fiber numbering.
         1). For example 144-fibers provided as two 72-fiber cables would be labeled "001-072" and "073-144".
   2. Cable size
      a. Actual cable size in number of fibers
   3. Feed from
      a. Location ID of far end frame
   4. Location where feed is from
      a. Building and Floor where feed is from
   5. Example 72 fiber cable from Building 221 service floor room 0:

0072 to 0144
072
2210
Bldg 221 svc floor

3.10 FIBER OPTIC PATCH PANELS

A. Label each fiber strand terminated in patch panel or workstation outlet with unique identifying code.

B. Patch panel labels shall be visible from front of panel without opening panel cover.

C. Place patch panel labels for fiber strands on manufacturer designated labeling areas.

D. Label Fiber Optic Patch Panels above each port with unique labeling code to identify:
   1. Fiber type
      a. FOMM = Fiber Optic Multimode
      b. FOSM = Fiber Optic Singlemode
   2. Point of Origin: TR-XX
      a. TR = TR room number
      b. XX = unique number for each fiber optic strand per cable
   3. Point of Destination: BDF-XX
      a. BDF = BDF room number
      b. XX = unique number for each fiber optic strand per cable
      c. Equipment Rack number is not required on fiber optic patch panels.

3.11 INNERDUCT

A. Innerduct containing fiber optic cable installed under this project shall be labeled where exposed.
   1. Includes areas where innerduct is installed in trays and in equipment rooms.

B. Label innerduct with durable Yellow Polyethylene tag that reads "CAUTION FIBER OPTIC CABLE"

1. Tag shall provide blank spaces for adding fiber count and cable destination information.

C. Label Tag to include:
   1. Identifier(s) of cable(s) contained therein.
      a. Use Backbone Cable labeling formats as described above.

D. Hand lettering is acceptable on tag
   1. Use an indelible type ink.

E. Tag shall be secured to Innerduct using self-locking ties.

3.12 TELECOMMUNICATIONS GROUNDS:

A. Label Grounds as close as practicable to point of termination.

B. Labels shall be non-metallic and include the following:

WARNING IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE CALL THE BUILDING TELECOMMUNICATIONS MANAGER.

End of Section

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SECTION 27 10 00

STRUCTURED CABLING

PART 1 - GENERAL

1.1 SCOPE

A. This section details product and execution requirements for Structured Cabling for Communications Systems.

1.2 DESCRIPTION

A. Systems shall include cabling, termination hardware and active components, installed as indicated on drawings and specifications.

B. Cables and equipment shall be provided, tested, and terminated, including proper grounding and bonding.

1.3 RELATED WORK

A. Related Division 27 Sections include:
1. Section 27 00 00 - General Communications Requirements
2. Section 27 05 26 - Grounding and Bonding for Communications Systems
3. Section 27 05 28.29 - Hangers and Supports for Communications Systems
4. Section 27 05 28.33 - Raceway and Boxes for Communications Systems
5. Section 27 05 28.36 - Cable Tray for Communications Systems
6. Section 27 05 28.39 - Surface Raceways for Communications Systems
7. Section 27 05 53 - Communications Systems Identification
8. Section 27 11 00 - Communications Equipment Room Fittings
9. Section 27 13 00 - Communications Backbone Cabling
10. Section 27 15 00 - Communications Horizontal Cabling
11. Section 27 16 00 - Communication Connecting Cords, Devices and Adapters.

B. Related sections in other Divisions of Work:
1. See individual technical sections identified above (if applicable).

1.4 REFERENCES AND STANDARDS

A. Refer to Section 27 0000 - General Communications Requirements which identifies pertinent References and Standards.

B. In addition:
1. TIA 568-C.0 through C.3 - Commercial Building Telecommunications Cabling Standard (including applicable Addenda)
2. TIA 569-B - Commercial Building Standard for Telecommunications Pathways and Spaces.
3. BICSI Telecommunications Distribution Methods Manual (TDMM)
4. TIA-598-C: Optical Fiber Cable Color Coding.
5. TIA 455-21-A: Mating Durability for Fiber Optic Interconnecting Devices
6. TIA 526-14A: Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
7. TIA-526-7: Optical Power Loss Measurements of Installed Single-mode Fiber Cable Plant

8. UL-910: Tests for Flame Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables used in Spaces Transporting Environmental Air
9. UL-1666: Tests for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
10. IEEE 802.3af and 802.3at Power-over-Ethernet Standards.
11. IEEE 802.3an 10 Gigabit Standard

1.5 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements for general terminology used in Division 27 sections.

B. In addition, the following definitions are applicable to communications environments and shall apply to this document and its companion sections for clarification and direction:

1. Backbone Cabling - cable or conductors between telecommunications rooms, or floor distribution terminals, entrance facilities, and equipment rooms within or between buildings. Backbone cabling may be twisted pair copper, fiber optic or coaxial.
2. Cable - assembly of 1 or more conductors or optical fibers within enveloping sheath, constructed so as to permit use of conductors singly or in groups.
3. Cable ID - unique alpha-numeric identification used for tagging of backbone or horizontal cabling.
4. Channel - end-to-end transmission path to which application-specific equipment is connected. Same as "Permanent Link", but also includes patch cords at Telecommunications Outlet and in Telecom Room.
5. Consolidation Point (CP): A location for interconnection between horizontal cables extending from the horizontal cross-connect and horizontal cables extending to the telecommunication outlet at the workstation.
6. Contractor - Telecommunications Contractor or sub-contractor(s) responsible for installation, termination, test and documentation of communications cabling, termination components, pathway hardware, telecommunications equipment room hardware and related components detailed in technical sections of this Division of work.
7. Cross-Connect - group of connection points between cabling runs and/or equipment used to administer building wiring using patch cords or wire jumpers.
8. Horizontal Cabling - Cables connecting Telecommunications Outlets to horizontal or intermediate cross-connect. Sometimes referred to as "Station Cabling".
9. Horizontal Cross-connect (HC) - Connection of horizontal cabling to other cabling (e.g. horizontal, backbone or equipment) using patch cords or wire jumpers..
10. Interconnection - Connection scheme using connecting hardware for the direct connection of a cable to another cable without a patch cord or jumper
11. Main Cross-connect (MC) - Connection between backbone cables, entrance cables and equipment cables using patch cords or wire jumpers.
12. Outlet ID - unique alpha-numeric identification used for referencing Telecommunications Outlet or connectors therein.
13. Permanent (Cable) Link - includes Telecommunications Outlet, horizontal (station) cable and termination hardware in Telecom Room.
14. Service Loop - Surplus cable, typically located at or near point of termination to enable future changes.
15. Telecommunications Outlet (TO) - device assembly located in work area on which horizontal cabling terminates and which can receive modular connectors. It is interface between Station Cable and end user's equipment.
16. Telecom Room - an enclosed space for housing telecommunications equipment, horizontal and backbone cable terminations, and cross-connect cabling, that is recognized location of horizontal cross-connect.

17. Zone Box - An enclosure used to house one or more of the following; a) a consolidation point, b) a horizontal connection point, c) building automation system outlets.
18. Zone Cabling - Extends permanent horizontal cabling to a shared termination (consolidation) point in the work area. Passive system extends link to workstation through at interconnect at the Consolidation Point (CP). Active system includes system electronics at the CP.

C. “10-gigabit” or “10G” performance criteria, if applicable, refers to support of 10GBASE-T application over 4-connector channel up to 100-meters and meeting requirements of TIA-568-B.2-10 “Transmission Performance Specifications for 4-Pair 100 Ohm Augmented Category 6 Cabling”.

1.6 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements for general terminology used in Division 27 sections.

B. In addition, the following abbreviations and acronyms shall apply to this document and its companion sections for clarification and direction:

1. 8P8C Eight-Position, Eight-Conductor. Used in clarifying jack type; a.k.a. "RJ-45".
2. CM Communications cable rated for General Purpose use
3. CMP Communications cable rated for use in Plenum areas
4. CMR Communications cable rated for use in Risers and vertical runs
5. CP Consolidation Point
6. ELFEXT Equal-Level Far-End Cross Talk (pair-to-pair)
7. FEXT Far-End Cross Talk
8. F/UTP Foiled Unshielded Twisted Pair
   No shielding around individual pairs and an overall foil shield under the cable jacket
9. HC Horizontal Cross-connect
10. HCP Horizontal Connection Point (e.g. for TIA-862)
11. IDF Intermediate Distribution Frame
12. MC Main Cross-connect
13. MDF Main Distribution Frame
14. N Newton
15. NEXT Near End Cross Talk
16. OFNP Optical Fiber Nonconductive Plenum
17. OFNR Optical Fiber Nonconductive Riser
18. OTDR Optical Time Domain Reflectometer
19. PBX Private Branch Exchange (Telephone Switch)
20. PoE Power-over-Ethernet
21. PSNEXT Power Sum Near End Cross Talk
22. S/FTP Screened Foiled Twisted Pair
    (Individual foil shield around each individual pair and an overall braided shield under the cable jacket.)
23. S/UTP Screened Unshielded Twisted Pair
    (No shielding around individual pairs and an overall braided shield under the cable jacket.)

24. SF/UTP Screened Foiled Unshielded Twisted Pair
    (No shielding around individual pairs and overall foil and braided shields under the cable jacket.)
25. TO Telecommunications Outlet
26. TR Telecommunications Room
27. USOC Universal Service Order Code
28. UTP Unshielded Twisted Pair
    (No shielding around pairs nor overall under cable jacket.)
29. U/FTP Unshielded Foiled Twisted Pair
    (Individual foil shield around each individual pair and no overall braided shield under the cable jacket.)

1.7 WORK BY LABORATORY

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Laboratory affecting sub-system(s) covered by this section.

1.8 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements which provides general guidelines for product or installation information to be submitted by Contractor.

B. In addition, Submit:
   1. Contractor Certification documents which document their participation in Installers Program operated by Manufacturer of Cabling or Termination Components used.
      a. Upon request, Certified Installer(s) assigned to Project shall be identified to Engineer.

1.9 QUALITY ASSURANCE

A. General:
   1. Cable and Equipment Manufacturer(s) shall be company specializing in communications cable, accessories and/or equipment with minimum of 5 years documented experience in producing cable, accessories and/or equipment similar to those specified herein.

B. Contractor Qualifications:
   1. Qualified personnel utilizing state-of-the-art equipment and techniques shall complete cable and equipment installation and termination.
   2. Contractor shall have been in this business for minimum of 5 years and shall have successfully completed 4 projects equal in magnitude of system specified in the following sections.

C. Contractor shall have necessary certifications to provide for Warranty as specified herein.
   1. Contractor shall be an active participant in Installers Program operated by Manufacturer of Cabling or Termination Components used.
      a. Contractor shall be participant in this program at time of Bidding and remain so throughout project.

1.10 GUARANTEE

A. See Division 1, General Conditions, and General Requirements - Guarantee Documents and Section 27 0000 - General Communications Requirements for general guarantee requirements.

B. Warranty structured cable system as follows:

1. 4-pair Category-rated Horizontal Copper Channel for no-less than 20 years from date of substantial completion of work.
2. Copper Backbone for no-less than 2 years from date of substantial completion of work. Cabling and Connecting Components shall carry 20 year component warranty.
3. Fiber Optic Backbone for no-less than 20 years from date of substantial completion of work.

C. Warranty shall be direct from manufacturer(s) of cabling and connecting components to Laboratory.

PART 2 - PRODUCTS

2.1 GENERAL

A. Refer to individual Technical Sections.

B. All cable and connecting components that comprise the TIA horizontal cabling “Permanent Link” from Horizontal Cross-connect to Telecommunications Outlet shall be compliant with the applicable requirements for “DTE Power via the MDI” to provide at least 25.5W at the Powered Device as defined by the IEEE 802.3at standard.

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to individual technical specification sections for detailed Cable Routing and Installation, Testing and Documentation requirements. The following apply to communications cabling and termination work.

B. Installation shall be per manufacturers' recommendations.

C. Label cables and termination components per Section 27 0553 - Communications Systems Identification.

3.2 CABLE INSTALLATION

A. Run cabling in raceways provided, or as designated on floor plans, and support from building structure.
   1. Where installed in free-air, support cables using J-hook type cable supports installed in accordance with manufacturer’s installation requirements. Refer to Section 27 0528.29 - Hangers and Supports for Communications Systems for installation requirements.
      a. J-hook fill capacities shall be per manufacturer’s recommendations and shall consider diameter of cable type(s) being installed.
      b. Route cable/hooks at right angles, parallel to construction.
   2. Where installed in Cable Tray, lay cables neatly in tray.
      a. Do not tie.
      b. Provide sufficient slack in cables to allow for unequal expansion coefficients of cable tray and cables. This requirement is in addition to slack required at cable tray expansion joints.

B. Route and support cable in Equipment Rooms and Telecom Rooms utilizing "D-type" mounting rings, J-hooks and overhead cable runway.

C. Cable shall be free of tension at both ends.
   1. In cases where cable must bear stress, provide Kellems grips to spread stress over longer length of cable.

D. Provide required installation tools to facilitate cable pulling without damage to cable jacket.

E. Keep cables clear of other trades work.

F. During pulling operation provide an adequate number of workers to allow cable observation at points of raceway entry and exit, as well as to feed cable and operate pulling machinery.

G. Pull cables in accordance with cable manufacturer's recommendations and ANSI/IEEE C2 Standards.

H. Pull cable by hand unless installation conditions require mechanical assistance.

I. Do not exceed recommended pulling tensions and bending radii.
   1. Where mechanical assistance is used, ensure that maximum tensile load for cable is not exceeded.
      a. This may be in form of continuous monitoring of pulling tension, use of "break-away" or other approved method.
   2. Replace cables bent or kinked to radius less than recommended dimension.
      a. This shall be at no expense to Laboratory.

J. Install cables splice-free unless otherwise specified.

K. Avoid abrasion and other damage to cables during installation.
   1. Visually inspect cables for cuts, blisters and abrasions during installation.

L. Pulling lubricant may be used and shall:
   1. Be non-injurious to cable jacket and other materials used.
   2. Not harden or become adhesive with age.

M. Repair damage to interior spaces caused by installation of cable, raceway or other hardware. Repairs must match preexisting color and finish of walls, floors and ceilings.

N. Replace contractor-damaged ceiling tiles to match color, size, style and texture.

O. Provide pull cord (200 lb minimum) with cable installed in conduit or innerduct.

P. Neatly lace, dress and support cabling.

Q. In vertical pathway, support cables on each floor using industry recognized support methods designed specifically for that purpose.
   1. Strap vertical runs as required, to prevent sagging of cables.

R. To reduce effects of EMI, adhere to the following minimum cable separation distances:
   1. 5" from power lines of 2 kVA
   2. 18" from high voltage lighting (including fluorescent)
   3. 39" from power lines of 5 kVA or greater
   4. 47" from transformers and motors

3.3 FIELD TESTING

A. Refer to Section 27 0000 - General Communications Requirements for general guidelines regarding requirements for scheduling and performing compliance testing.

B. Cabling shall be 100% fault free unless otherwise noted. If any Channel is found to be outside specification defined herein, identify and correct problem up to and including replacement of cable and associated termination(s). Then repeat applicable tests.

C. Test each cabling sub-system (e.g. backbone, horizontal, etc.) end-to-end.

D. Where sub-systems are to be interconnected or cross-connected by the contractor, test individual sub-system followed by a test of the connected links
   1. Performance and documentation requirements shall default to the lesser of the two connected systems if different.
   2. Example 1: Combined Backbone-Horizontal Link
      a. Test and document individual Backbone and Horizontal Cabling Sub-systems.
      b. Cross-connect sub-systems.
      c. Repeat testing on combined cabling from MC - TO, through HC.
      d. Performance and documentation requirements shall be based in this example on backbone cabling (continuity, pair integrity, etc.).
   3. Example 2: Interconnected Zone Cabling Link
      a. Test and document individual HC – CP links.
      b. Install interconnect cabling CP - TO
      c. Repeat testing on combined cabling from HC - TO through CP.
      d. Performance and documentation requirements shall be based in this example on TIA Permanent Link for Horizontal Cabling.

E. Test instrument shall be configured using template for exact cable under test (e.g. by manufacturer product designation).
   1. If no template is available, enter cable parameters for the cable per manufacturer’s product data.
      a. Nominal Velocity of Propagation (NVP) used for copper cable type under test shall be traceable to manufacturers' product data.
      b. Refractive Index used for fiber optic cable type under test shall be traceable to manufacturers' product data.
   2. Test results obtained using incorrect cable parameters will be rejected.

F. Refer to individual Technical Sections for system-specific guidelines regarding requirements for scheduling and performing compliance testing.

3.4 DOCUMENTATION

A. Refer to Section 27 0000 - General Communications Requirements for general guidelines regarding requirements for project Documentation.

B. Refer to individual Technical Sections for system-specific guidelines regarding requirements for project Documentation.

End of Section

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SECTION 27 11 00

COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 SCOPE

A. This section details product and execution requirements for Communications Equipment Room Fittings for Communications Systems.

1.2 DESCRIPTION

A. Communications Equipment Room Fittings include:
   1. Cabinets, Racks, Frames and Enclosures
   2. Cable Runway
   3. Termination Blocks
   4. Patch Panels
   5. Entrance Protection

B. Refer to Project Drawings for Equipment Room layout and equipment placement.

1.3 RELATED WORK

A. Refer to Section 27 0000 - General Communications Requirements which identifies related specification sections in this and other Divisions (if applicable).

1.4 REFERENCES AND STANDARDS

A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. Related Division 27 Sections include:
   1. Section 27 00 00 - General Communications Requirements
   2. Section 27 05 26 - Grounding and Bonding for Communications Systems
   3. Section 27 05 28.29 - Hangers and Supports for Communications Systems
   4. Section 27 05 28.33 - Raceway and Boxes for Communications Systems
   5. Section 27 05 28.36 - Cable Tray for Communications Systems
   6. Section 27 05 28.39 - Surface Raceways for Communications Systems
   7. Section 27 05 53 - Communications Systems Identification
   8. Section 27 10 00 - Structured Cabling
   9. Section 27 13 00 - Communications Backbone Cabling
   10. Section 27 15 00 - Communications Horizontal Cabling
   11. Section 27 16 00 - Communication Connecting Cords, Devices and Adapters

C. Related sections in other Divisions of Work:
   1. See individual technical sections identified above (if applicable).

1.5 DEFINITIONS

A. Refer to Section 27 0000 -General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Definitions used in this and related sections.

1.6 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 -General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Abbreviations and Acronyms used in this and related sections.

1.7 WORK BY LABORATORY

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Laboratory affecting sub-system(s) covered by this section.

1.8 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide general guidelines for product or installation information to be submitted by Contractor.

1.9 QUALITY ASSURANCE

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identify general quality assurance requirements for the Project.

1.10 GUARANTEE

A. Refer to Division 1, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.

B. Refer to Section 27 1000 - Structured Cabling for particular Warranty requirements for Structured Cabling. Those requirements apply to cable and components covered in this section.

PART 2 - PRODUCTS

2.1 CABINETS, RACKS, FRAMES AND ENCLOSURES

A. Manufacturer: Ortronics

B. Equipment racks shall be Mighty Mo 6 cable management rack part number OR-MM6716

C. Wall mounted equipment cabinet shall be Mighty Mo wall mount cabinet part number OR-MMW262426S-B.

D. Cable Management
   1. Manufacturer: Ortronics
   2. Horizontal Cable Management Panels shall be Mighty Mo 6 part number OR-MM6HMF2RU
   3. Vertical Cable Management shall be Mighty Mo 6 part number OR-MM6VMD710

E. Equipment Rack Ground Busbar
   1. Material: Copper
   2. Mounts horizontally in rack
   3. Mounting configuration EIA universal mounting hole pattern, tapped #12-24.

F. Miscellaneous

1. Releasable Cable Support Ties shall be:
    a. Hook & Loop type.
    b. Individual units with latch.
        1). Roll of hook & loop material is not acceptable.

2.2 CABLE RUNWAY

A. Manufacturers: CPI, B-Line.

B. Cable Runway shall:
1. Be constructed of 0.065" thick steel
2. Utilize tubular stringers to support rungs.
    a. Stringers shall be 1-1/2" high.
    b. Rungs shall be welded to stringers and shall be spaced 9" on center.
3. Be painted with black epoxy.

C. Runway width(s) shall be as shown on drawings.

2.3 TERMINATION BLOCKS

A. Manufacturers: CommScope Systimax, Ortronics

B. Blocks shall be 110-style high-density cross-connect blocks.

C. Each horizontal row of block shall be capable of terminating one 25 pair binder group of Backbone Copper Cable, or six 4 pair Copper Cables.

D. Mechanical termination on blocks shall:
1. Have ability to terminate 22-26 AWG plastic insulated, solid and stranded copper conductors.
2. Provide direct connection between horizontal or backbone cable and jumper wires.
3. Be designed to maintain cable pair twists as closely as possible to point of mechanical termination.

E. Blocks for backbone cabling shall use 5-pair connecting blocks.
1. Blocks shall identify pair position by color designation.
    a. Colors shall be Blue, Orange, Green and Brown for Horizontal Cables.
    b. Colors shall be Blue, Orange, Green, Brown and Slate for Backbone Cables.
    c. Markings shall designate Tip and Ring conductors.

F. Backbone Voice Blocks shall:
1. Be Systimax 110 “A” blocks
2. Be wall-mounted with legs
3. Meet or exceed TIA Category 6 performance criteria
4. Terminate up to 100-pairs (each block)

G. Distribution frame shall be:
1. Ortronics Mighty Mo 110D frame
2. Wall-mountable

2.4 MODULAR PATCH PANELS:

A. Manufacturer: CommScope Systimax

B. Station cable panels shall be:
   1. 360-iP-1100-E-GS6-1U-24 (24-port)
   2. 360-iP-1100-E-GS6-2U-48 (48-port)
   3. Wired per TIA 568B pinning standard.

C. Backbone cable panels shall be:
   1. 360-iP-1100-GS5-24 (24-port)
   2. 360-iP-1100-GS5-48 (48-port)

2.5 FIBER OPTIC PATCH PANELS

A. Manufacturer: CommScope Systimax

B. Patch Panels shall be:
   1. Part number 360-IP-G2-1U-LC-SD
   2. Rack mountable on standard TIA/EIA 19" equipment racks

C. Connector Modules shall snap into patch panel enclosure.

D. Other parts which may be necessary to provide a working fiber optic system shall include:
   1. Splice tray, part number RS-2AF-16SF
   2. Splice organizer, part number SW-6AF-16SF
   3. Fusion splice tray, part number 1AMF1-16LG

E. Incoming cables shall not be accessible from patching area of panel.
   1. Enclosure shall provide physical barrier to access of such cables.
   2. Where factory-terminated cable assemblies ("pigtails") are spliced to cable, enclosure shall incorporate hardware for securing of splice tray and required cable, buffer tube and pigtail slack.

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to project Drawings for communications equipment room layout and equipment placement.

B. New communications equipment rooms must be free from dust, dirt, and other foreign materials before installation of any termination hardware or termination of copper or fiber optic cables.
   1. Door to room must be closed during termination if area outside room is not dust-free.

C. Follow manufacturer’s recommended installation and termination practices.

D. Provide necessary assistance to allow Laboratory or Carrier personnel to establish service on new cable system.
   1. Includes general wiring overview, cable pair identification, and cross connect documentation (if applicable).

3.2 CABINETS, RACKS, FRAMES AND ENCLOSURES

A. Provide equipment racks and wall mounted cabinets as shown on project Drawings.

B. Assemble racks per manufacturer’s recommendations. Remove paint at the point(s) of contact of assembly hardware or use internal-external tooth lock washers to pierce paint to maintain ground continuity.

C. Bolt racks to floor.

D. Secure racks to cable runway as described below.

E. Secure wall mounted cabinets to wall per manufacturer requirements to support cabinet load rating.

F. Provide Horizontal and Vertical Cable Management in equipment racks per project Drawings

G. Provide each rack with:
   1. Ground bar and #6 AWG Ground lug,
   2. Minimum of fifty (50) 12/24 mounting screws,
   3. Minimum of twelve (12) releasable (e.g. "hook & loop") cable support ties.

H. Bond each rack mounted ground bar to telecommunications ground bus bar (TGB).
   1. Use #6 or larger AWG copper conductor (green jacket).

3.3 CABLE RUNWAY

A. Provide cable runway and accessories necessary for complete system.

B. Size and layout of cable runway shall be as shown on project Drawings.

C. Install above equipment racks as shown on drawings.

D. Align with equipment racks as shown on drawings

E. Brace to racks with support brackets made by runway or rack manufacturer intended for this purpose.

F. Use radius drops where cables drop from tray to rack and at elevation changes of 6" or more.

G. Maximum allowable deviation of runway from level horizontal plane measured across length of cable runway shall be 1/2", with tray loaded to capacity.

H. Where cable runway is supported from building structure:
   1. Provide 3/8" threaded rods for support of 12" wide or smaller runway.
   2. Provide 1/2" threaded rods for support of runway greater than 12" in width.

I. Bond runway components together using manufacturer's standard accessories.

J. Fasten cables to runway at intervals not to exceed 4 ft.

3.4 TERMINATION BLOCKS

A. Provide blocks per project documents.

B. Prepare cables and terminate per manufacturer’s recommendations.

C. Provide 110 blocks as follows:
   1. Backbone Voice Cabling at main cross-connect on wall-mounted distribution frame.

D. Install Blocks on frame:
   1. No higher than 72" AFF to top-most block
   2. Top to bottom, left to right
   3. Frame shall be mounted no closer than 12" from left wall

E. Cabling entering and exiting fields shall be neatly laced, dressed and supported.

F. Contractor shall not be responsible for jumper wiring between horizontal and backbone cabling.

3.5 MODULAR PATCH PANELS

A. Provide panels per project documents.
   1. Provide panel managers and other components necessary for a fully functional iPatch system.
   2. Coordinate iPatch setup with Laboratory and integrate into existing campus system as required.

B. Mount patch panels in 19" equipment racks.

C. Position cables in sequence of:
   1. Telecommunications Outlet ID for horizontal cabling
   2. Pair number for backbone cabling

D. Provide horizontal management below each patch panel.

E. Provide minimum of 4 screws to secure each patch panel onto rack.

3.6 FIBER OPTIC PATCH PANELS

A. Provide Fiber Optic Patch Panels and coupling assemblies as shown on drawings.
   1. Provide minimum of 4 screws to secure each patch panel onto rack.

B. Provide couplings in coupling assemblies and mount coupling assemblies and blank covers in patch panels.

C. Position fibers consecutively - starting with lowest number - and mapped "position for position" between patch panels.
   1. There shall be no transpositions in cabling.

D. Keyways on duplex couplings shall be oriented to establish "cross-over" in cabling system.
   1. Convention defined by TIA/EIA-568-C.3 (Section 6.4.2.1) shall be used.
   2. Reverse-pair positioning shall not be used.

E. Provide blank covers for unused coupling assembly spaces in panels.

F. Clean couplings with foam swab and isopropyl alcohol prior to connector insertion. Blow dry with compressed air.

G. Provide dust caps for couplings.

H. Where factory-terminated cable assemblies ("pigtails") are spliced to cable, prepare and splice cables and fibers per manufacturers' guidelines.

3.7 FIELD TESTING

A. General
   1. Refer to Section 27 0000 - General Communications Requirements and 27 1000 – Structured Cabling for guidelines regarding documentation requirements.
   2. Refer to referenced technical sections for detailed requirements to testing of each cable sub-system.

3.8 DOCUMENTATION

A. General

1. Refer to Sections 27 0000 - General Communications Requirements and 27 1000 – Structured Cabling for guidelines regarding documentation requirements.

End of Section

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SECTION 27 13 00

COMMUNICATIONS BACKBONE CABLING

PART 1 - GENERAL

1.1 SCOPE

A. This section details product and execution requirements for backbone cabling for Communications Systems.

1.2 DESCRIPTION

A. Backbone Cabling links telecommunications rooms or floor distribution terminals, entrance facilities, and equipment rooms within or between buildings.

B. Backbone cable types include:
   1. Twisted-Pair Copper
   2. Fiber Optic

C. See Project Drawings which detail Backbone Cable System topology and conductor/fiber counts.

1.3 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 00 00 - General Communications Requirements
   2. Section 27 05 26 - Grounding and Bonding for Communications Systems
   3. Section 27 05 28.29 - Hangers and Supports for Communications Systems
   4. Section 27 05 28.33 - Raceway and Boxes for Communications Systems
   5. Section 27 05 28.36 - Cable Tray for Communications Systems
   6. Section 27 05 28.39 - Surface Raceways for Communications Systems
   7. Section 27 05 53 - Communications Systems Identification
   8. Section 27 10 00 - Structured Cabling
   9. Section 27 11 00 - Communications Equipment Room Fittings
   10. Section 27 15 00 - Communications Horizontal Cabling
   11. Section 27 16 00 - Communication Connecting Cords, Devices and Adapters

B. Related sections in other Divisions of Work:
   1. See individual technical sections identified above (if applicable).

1.4 REFERENCES & STANDARDS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identify pertinent References and Standards.

1.5 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Definitions used in this and related sections.

1.6 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Abbreviations and Acronyms used in this and related sections.

1.7 WORK BY LABORATORY

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Laboratory affecting sub-system(s) covered by this section.

1.8 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide general guidelines for product or installation information to be submitted by Contractor.

B. In addition, submit:
   1. One 3-foot section of each cable type from cable reels sent to site for Engineer's final approval.
      a. Section shall have manufacturer's cable markings visible.

1.9 QUALITY ASSURANCE

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identify general quality assurance requirements for the Project.

1.10 GUARANTEE

A. Refer to Division 1, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.

B. Refer to Section 27 1000 - Structured Cabling for particular Warranty requirements for Structured Cabling. Those requirements apply to all cable and components covered in this section.

PART 2 - PRODUCTS

2.1 GENERAL

A. Cables and Termination hardware shall be technically compliant with and installed in accordance with referenced TIA/EIA documents.

B. Cables shall be Underwriters Laboratory (UL) listed, comply with Article 800 (Communications Circuits) of National Electrical Code and shall meet specifications of NEMA (low loss), UL 444, and ICEA (where applicable).

2.2 TWISTED PAIR CABLING

A. General:
   1. Manufacturers: CommScope, Superior Essex, Mohawk CDT
   2. Cable shall be standard exchange type telephone cable.
      a. This is defined as paired multi-conductor, thermoplastic insulated, copper cable characterized by an average mutual capacitance of 83 (+4/-5) nano-Farads per mile at 1000 Hz.
   3. Cabling shall:
      a. Be constructed of individually twisted pairs.
      b. Be suitable for installation in environment defined.

c. Be packaged to minimize tangling and kinking of cable during installation.

4. Identify conductors by insulation color.
5. Color code shall follow industry standard of 10 distinctive colors to identify 25 pairs.
   a. Marking of each mate of primary conductor in pair with color of that primary conductor is optional.
6. When cables of larger than 25 pairs are required, cable core shall be assembled into 25-pair sub-units.
7. Wrap super units with solid color thread that follows primary color scheme of white, red, black, yellow and violet.
8. Cable jacket shall be marked at 2 ft intervals indicating manufacturers' identification, pair count, AWG and sequential footage.

B. Backbone UTP Cable (Intra-building):
1. Cable Shall Meet following minimum requirements:
   a. Size: 24 AWG solid annealed copper pairs
   b. Number of Pairs: as shown on Project Documents
   c. Impedance: 100 Ohms ± 15%
   d. Jacket Color: Black or Grey
   e. Jacket Type: PVC
   f. Shield: Overall, continuous corrugated aluminum bonded to outer jacket
   g. Cable Rating: NEC Article 800 Type CMR, UL listed

2.3 FIBER OPTIC CABLE

A. General
1. Manufacturer: CommScope Systimax
2. Fibers utilized in installed cable shall be traceable to manufacturer.

B. Optical Fiber - General
1. Optical fibers shall:
   a. Be sufficiently free of surface imperfections and occlusions to meet optical, mechanical, and environmental requirements of this specification.
   b. Have been subjected to minimum tensile proof test by fiber manufacturer equivalent to 100-kpsi.
2. Factory optical fiber splices are not allowed.
3. Coatings shall be mechanically strippable without damaging optical fiber.

C. Indoor Backbone Fiber Optic Cable
1. Multimode cable shall be part number R-012-DS-5K-FSUAQ
2. Singlemode cable shall be part number R-012-DS-8W-FSUYL

2.4 FIBER OPTIC CONNECTOR MODULES

A. Manufacturers: CommScope Systimax

B. Connector modules shall be:
1. Multi-mode part number 12-LC-LS-AQ-pigtails
2. Single-mode part number 12-LC-SM-BL-pigtails

PART 3 - EXECUTION

3.1 CABLE INSTALLATION AND TERMINATION

A. General
1. Provide 50 pair copper cable between BDF and TR.
2. Provide (1) single mode and (1) multimode fiber optic cable between BDF and TR.
3. Provide (1) multimode fiber optic cable between BDF and Room O119.
4. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling for general cable installation requirements.

B. Backbone UTP Voice Cable:
1. Terminate cables on backbone voice cable blocks in BDF and modular patch panels in TR.
a. Maintain cables pair twists to within 1" of termination.
b. Remove cable jacket only to extent required to make terminations.
c. Terminate each riser pair directly to pins 4 and 5 of the riser patch panel jacks.

C. Fiber Optic Cable
1. Route backbone fiber optic cable in innerduct.
2. Ground any metallic cable elements (if applicable) per Code.
3. Terminate fiber strands on pigtail connectors mounted in Fiber Optic Patch Panels.
a. Terminate all fibers.
4. Follow manufacturer's guidelines for connector type(s) provided.
a. Clean connectors with lint-free pad saturated with 90% to 100% isopropyl alcohol after fiber termination. Wipe with dry, lint-free pad and blow end face with compressed air for minimum of 5 seconds.
5. Provide cable slack in each backbone fiber optic cable.
a. Slack shall be in addition to length of fiber required for termination requirements.
b. Store cable slack in enclosure designed for this purpose.
c. Slack required shall be as follows:
1). Backbone Intra-Building: Minimum of 5 meters (each cable if applicable) coiled and secured at one end (preferably at Telecom Room).

3.2 FIELD TESTING

A. General
1. Refer to Section 27 0000 - General Communications Requirements for general guidelines regarding requirements for scheduling and performance of compliance testing.
a. Contractor shall be responsible for testing each system end-to-end.

B. Backbone UTP Cable Testing
1. Verify voice cable pairs for wire map (transposed/reversed/split pairs) and shorts through toning of each conductor.
2. Verify cable shield or coupled bonding conductor for end-to-end continuity.

C. Backbone Fiber Optic Cable Testing
1. Pre-Installation Testing
a. Pre-installation testing shall be done at contractor option.

b. Submit cable manufacturer's test report for each reel of cable provided.
   1). Verify fiber attenuation, bandwidth and length values as specified on cable data sheets supplied with cable reels.
c. Visually inspect reels and packaging for damage.

2. Post-Installation Testing
   a. Testing shall include:
      1). Optical Attenuation
      2). Optical Time Domain Reflectometry (OTDR)
      3). Optical Return Loss
   b. Optical Attenuation
      1). Light Source: VCSEL for 850-nm tests; FP LASER for 1300-nm tests
      2). Measure Optical Attenuation on terminated fibers.
         a). Include optical connectors and couplings installed at fiber endpoints.
      3). Test multimode fibers using EIA/TIA 526-14A, Method B.
      4). Test single-mode fibers using EIA/TIA 526-7-1998. Method A.1.
      5). Test all fibers in both transmission directions.
      6). Test multimode fibers at 850 ± 30 nm and 1300 ± 20 nm wavelengths.
      7). Test single-mode fibers at 1310 ± 10 nm and 1550 ± 10 nm wavelengths.
      8). Fiber lengths less than or equal to 300 ft shall test to ≤ 2.0 dB loss.
      9). Fiber lengths greater than 300 feet shall test to loss value less than link loss budget for installed connectors and fibers.
   c. Optical Time Domain Reflectometry (OTDR)
      1). Verify integrity of all fibers - using an Optical Time Domain Reflectometer (OTDR).
         a). Includes terminated and (if applicable) un-terminated fibers.
      2). OTDR(s) shall incorporate high-resolution optics and short pulse-width options optimized for viewing of short cable sections.
         a). Pulse-width shall be 10-ns or less.
      3). OTDR traces shall be performed in one direction using access jumpers at transmit and receive ends.
         a). Minimum length of access jumper at launch end shall be minimum 100 meters long for multimode or 300-meters long for single-mode, unless recommended otherwise by test equipment manufacturer.
      4). Test multimode fibers at 850 ± 30 nm wavelength.
      5). Test single-mode fibers at 1310 ± 10 nm wavelengths.
      6). Examine traces for continuity and anomalies to confirm fiber link integrity.
         a). Point discontinuities in excess of 0.2 dB for multimode fibers or 0.1 dB for single-mode fibers shall be cause for rejection of cable.
         b). Any reflection in trace - except at patch panels - shall be cause for rejection of cable.
      7). OTDR tested links showing excessive backscatter immediately following connector shall have connector cleaned and/or re-polished and then retested.
   d. Optical Return Loss
      1). Testing shall include Optical Return Loss (ORL) measurement for each installed single mode fiber optic connector. Follow OTDR manufacturer's requirements for required tester settings, including scattering coefficient.
      2). Perform ORL with a Back Reflection Meter or an OTDR.

a). OTDR shall be capable of measuring fiber connector reflectance and produce accurate (± 2 dB) reflectance measurements

3). Test result cursors shall be placed at appropriate locations before tests are submitted for review. OTDR testers including automatic cursor positioning functions shall use said functions to position cursors accurately for measurement.

3.3 DOCUMENTATION

A. General

1. Refer to Section 27 0000 - General Communications Requirements for general guidelines regarding documentation requirements.

B. Backbone Copper Cable

1. Document pair count assignments by cable.

C. Backbone Fiber Optic Cable

1. Files containing Attenuation and OTDR traces of individual optical fiber "signatures" shall be so named as to identify each individual fiber by location in cable system and fiber number or color.
2. OTDR test results shall be consistent in format and presentation, including:
   a. Scale
      1). Scale or window of test result view shall show only enough trace to view fiber under test plus launch cords at both ends.
      2). View shall not show backscatter beyond end of fiber.
   b. Pulse width
   c. Units (English or Metric)
   d. Cursor placement
   e. Labeling

End of Section

SECTION 27 15 00

COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SCOPE

A. This section details product and execution requirements for Horizontal (Station) Cabling subsystem for Communications Systems.

1.2 DESCRIPTION

A. Horizontal cabling subsystem is portion of communication link that connects horizontal or intermediate cross-connect (typically at Telecom Room) and Telecommunications Outlet.

B. Horizontal Cable types include:
   1. 4-pair Copper Unshielded Twisted Pair (UTP)

1.3 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 00 00 - General Communications Requirements
   2. Section 27 05 26 - Grounding and Bonding for Communications Systems
   3. Section 27 05 28.29 - Hangers and Supports for Communications Systems
   4. Section 27 05 28.33 - Raceway and Boxes for Communications Systems
   5. Section 27 05 28.36 - Cable Tray for Communications Systems
   6. Section 27 05 28.39 - Surface Raceways for Communications Systems
   7. Section 27 05 53 - Communications Systems Identification
   8. Section 27 10 00 - Structured Cabling
   9. Section 27 11 00 - Communications Equipment Room Fittings
   10. Section 27 13 00 - Communications Backbone Cabling
   11. Section 27 16 00 - Communication Connecting Cords, Devices and Adapters.

B. Related sections in other Divisions of Work:
   1. See individual technical sections identified above (if applicable).

1.4 REFERENCES AND STANDARDS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identifies pertinent References and Standards.

1.5 DEFINITIONS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Definitions used in this and related Sections.

B. In this section, "Telecommunications Outlet" is considered to consist of Frame / Faceplate into which Modular Jacks or other couplings snap, Modular Jacks, blanks fitted to unused jack positions, and labeling/identification components.

1.6 ABBREVIATIONS AND ACRONYMS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide information on Abbreviations and Acronyms used in this and related Sections.

1.7 WORK BY LABORATORY

A. Refer to Section 27 0000 - General Communications Requirements which identifies Work by Laboratory affecting sub-system(s) covered by this section.

1.8 SUBMITTALS

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide general guidelines for product or installation information to be submitted by Contractor.

B. In addition, submit:
   1. Samples of each Telecommunications Outlet Faceplate type to confirm color and material.
   2. One 3 ft section of each cable type from cable reels sent to site for Engineer's final approval.
      a. Section shall have manufacturer's cable markings visible.
   3. Nominal Velocity of Propagation (NVP) for 4-pair Horizontal Copper Cable.

1.9 QUALITY ASSURANCE

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identify general quality assurance requirements for the Project.

1.10 GUARANTEE

A. Refer to Division 1, General Conditions, and General Requirements - Guarantee Documents for general warranty requirements.

B. Refer to Section 27 1000 - Structured Cabling for particular Warranty requirements for Structured Cabling. Those requirements apply to all cable and components covered in this section.

PART 2 - PRODUCTS

2.1 GENERAL

A. Cables and Termination hardware shall be technically compliant with and installed in accordance with referenced TIA/EIA documents.

B. Cables shall be Underwriters Laboratory (UL) listed, comply with Article 800 (Communications Circuits) of National Electrical Code and shall meet specifications of NEMA (low loss), UL 444, and ICEA (where applicable).

C. Horizontal (Station) Cable and Termination Components (Jack, Patch Panel) are specified to function as System.
   1. Where required for warranty purposes, manufacturers of cabling and termination components used (if more than one) shall recognize each other in their Certification Programs.

D. 4-Pair Horizontal Copper Cables and Modular Jacks are application independent (e.g. no distinction between “voice” and “data”).

2.2 4-PAIR HORIZONTAL COPPER CABLE

A. Manufacturer: CommScope Systimax
   1. GigaSPEED X10D

B. Cables shall be suitable for installation in environment defined

C. Cabling shall be packaged to minimize tangling and kinking of cable during installation.

D. Horizontal Copper Cable:
   1. Shall be part number 1091B
   2. Jacket color shall be Blue

2.3 TELECOMMUNICATIONS OUTLET

A. Manufacturer: CommScope Systimax

B. Connectors (modular jacks) shall snap onto faceplate.
   1. In surface-mount designs (if applicable) Jacks and connectors may mount to frame onto which coverplate is mounted.
   2. Dust covers for unused faceplate jack openings shall be part number M21A-262

C. Work Area Faceplate
   1. Wall-mounted faceplates intended to be used in general work areas shall be part number M13L-262
   2. Faceplates intended to be used in laboratory workbenches shall be part number M13L-262

D. Wall-mount Telephone Faceplate
   1. Faceplates intended to be used in locations where wall mounted telephone set is required shall be part number M10LW4

E. Faceplate - Wireless Access Point Location
   1. Faceplates supporting Wireless Access Point (AP) shall be part number M10L-262

F. Faceplate - In Floor
   1. Faceplates intended to be used in in-floor locations shall be part number M12L-262

G. Faceplate - Surface Raceway
   1. Faceplates intended to be used on surface raceway shall be part number M106FR4-262.

H. Faceplate - Modular Furniture
   1. Faceplates intended to be used on modular furniture shall be part number M13C-262.

2.4 MODULAR JACK

A. Manufacturers: See "Telecommunications Outlet" above.

B. Jack shall be part number MGS600-318

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to project Drawings for outlet locations.

B. Provide Modular Jacks in faceplates as shown on Project Documents.
   1. Provide 1 faceplate per Telecommunications Outlet symbol shown on Project Documents.
   2. Provide 1 modular furniture mounted faceplate per modular furniture symbol shown on Project Documents.

C. Maximum 4-pair Category-rated horizontal cable length shall not exceed 295 ft (90 meters) measured from horizontal cross-connect (typically at TR) to Telecommunications Outlet.
   1. Includes slack required for installation and termination.
   2. Contractor is responsible for installing station cable to avoid unnecessarily long runs.
   3. Any area that cannot be reached within above constraints shall be identified and reported to Engineer prior to installation.

D. Follow manufacturers recommended termination practices.

3.2 CABLE INSTALLATION AND TERMINATION

A. General
   1. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling for general cable installation requirements.
   2. Provide "Service Loop" for every Horizontal Cable in ceiling above outlet.
      a. Loop length shall be 3.3 ft (1 meter)
      b. Total length of 4-pair Category-rated horizontal cable including loop shall not exceed 295 ft.
      c. Place loop in ceiling at last support (e.g. J-Hook) before cables enter fishable wall, conduit, surface raceway or box.
      d. Coil loop in figure 8 configuration.
      e. Loop radius (minimum) shall be 4X minimum bend radius for cable.
   3. During installation, minimum bend radius shall be eight times outside diameter of UTP cables and 20 times outside diameter of fiber cables.
   4. Limit size of cable bundles along cable pathways and in communications equipment rooms to maximum of 12-24 cables.
   5. Route 10G UTP cable and other UTP cable categories independently. Do not bundle or share conduits. In cable tray, segregate cable types using a physical barrier.

B. Horizontal Copper Twisted-Pair Cabling
   1. Provide horizontal copper twisted pair cable between horizontal cross connect (typically at Telecommunications Room) and Telecommunications Outlet.
   2. At Telecommunications Outlet, terminate each 4-pair Horizontal Cable on 8P8C Modular Jack.
      a. Terminating one cable on more than one jack is not allowed.
   3. At horizontal cross-connect, terminate:
      a. Each 4-pair cable on 8P8C Modular Jack in Patch Panel.
   4. Terminate cables using 568B wiring standard.
   5. Cable jacket shall be continuous to within 1/2" of termination.
   6. Preserve pair twists to point of termination.
   7. Refer to Section 27 1100 - Communications Equipment Room Fittings for termination instructions for Modular Patch Panel and Termination Block.

3.3 TELECOMMUNICATIONS OUTLET

A. Faceplates shall be configured to provide connectivity as required by location. Refer to drawings.

B. Mount modular jacks and connectors into faceplates and secure faceplates to outlet box, raceway or modular furniture.
   1. Use faceplate extender if required to provide adequate clearance between jack and furniture or raceway panel to maintain minimum cable bend radius.
   2. Provide blank(s) in unused jack/connector positions. Match color of blank to faceplate color.

C. Position Telecommunications Outlet for wall-mounted telephone in area clear of other utilities and wall mounted hardware.
   1. Coordinate with other trades to maintain 8" clear space (minimum) on all sides from faceplate centerline.

3.4 FIELD TESTING

A. Refer to Sections 27 0000 - General Communications Requirements and 27 1000 – Structured Cabling for guidelines regarding testing requirements common to all Division 27 Structured Cabling sections.
   1. In addition, refer to sub-sections below for cable type under test.

B. 4-Pair Horizontal Copper Cable
   1. Test from:
      a. Horizontal Cross-connect (HC) to Jack at Telecommunications Outlet (TO).
   2. Testing shall be per TIA/EIA-568 Permanent Link test configurations.
   3. Maximum length of station cable shall not exceed 90 meters.
   4. Cables shall be free of shorts within pairs, and be verified for Continuity, Pair Validity and Polarity, and Wire Map (Conductor Position on Modular Jack).
      a. Identify and correct defective, split or mis-positioned pairs.
   5. In addition to above, Performance Testing shall be performed on all cables. Testing of Transmission Performance shall include the following:
      a. Length
      b. Insertion Loss / Attenuation
      c. Pair-to-pair NEXT
      d. PSNEXT
      e. Pair-to-pair ELFEXT (Equal Level Far End Cross-talk)
      f. PSEFEXT
      g. Return Loss
      h. Propagation Delay
      i. Delay Skew
      j. Alien Crosstalk (AXTalk)
         1). AXTalk measurement method shall be as required by the manufacturer(s) of cabling/connecting components installed to certify the system for warranty.
   6. Test cables to maximum frequency defined by standards covering specified performance category.
   7. Perform Transmission Performance Testing using test instrument designed for testing to specified frequencies.
      a. Test records shall verify "PASS" on each cable and display specified parameters - comparing test values with standards based "templates" integral to unit.

3.5 DOCUMENTATION

A. Refer to Sections 27 0000 - General Communications Requirements and 27 1000 – Structured Cabling for documentation guidelines.

B. Information added by Contractor to Record Drawings relating to Horizontal Cabling shall include cable routes, outlet locations and numbering and other detail necessary to document cable installation.

End of Section

SECTION 27 16 00

COMMUNICATIONS CONNECTING CORDS, DEVICES AND ADAPTERS

PART 1 - GENERAL

1.1 SCOPE

A. This section details product and execution requirements for Communications Connecting Cords, Devices and Adapters for Communications Systems.

1.2 DESCRIPTION

A. Included products described in Part 2 are:
   1. 4-pair Modular Patch Cords
   2. Modular-to-110 Patch Cords
   3. Fiber Optic Patch Cords - Multimode
   4. Fiber Optic Patch Cords - Single-mode

B. Refer to Part 3 of this Section for quantity and length of each item.

1.3 RELATED WORK

A. Related Division 27 Sections include:
   1. Section 27 00 00 - General Communications Requirements
   2. Section 27 10 00 - Structured Cabling
   3. Section 27 11 00 - Communications Equipment Room Fittings
   4. Section 27 13 00 - Communications Backbone Cabling
   5. Section 27 15 00 - Communications Horizontal Cabling

B. Related sections in other Divisions of Work:
   1. See individual technical sections identified above (if applicable).

1.4 REFERENCES AND STANDARDS

A. Refer to Sections 27 0000 - General Communications Requirements and 27 1000 -Structured Cabling which identify pertinent References and Standards.

1.5 DEFINITIONS

A. Refer to Sections 27 0000 - General Communications Requirements and 27 1000 - Structured Cabling which provide information on Definitions used in this and related sections.

1.6 ABBREVIATIONS AND ACRONYMS

A. Refer to Sections 27 0000 - General Communications Requirements and 27 1000 - Structured Cabling which provide information Abbreviations and Acronyms used in this and related sections.

1.7 WORK BY LABORATORY

A. Refer to Section 27 0000 -General Communications Requirements which identifies Work by Laboratory affecting sub-system(s) covered by this section.

1.8 SUBMITTALS

A. Refer to Sections 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which provide general guidelines for product and/or installation information to be submitted by Contractor.

1.9 QUALITY ASSURANCE

A. Refer to Section 27 0000 - General Communications Requirements and Section 27 1000 - Structured Cabling which identify general quality assurance requirements for project.

B. In addition:
   1. Patch Cords shall be 100% factory tested.

1.10 GUARANTEE

A. See Division 1, General Conditions, and General Requirements - Guarantee Documents and Section 27 0000 - General Communications Requirements for general guarantee requirements.

B. Communications Connecting Cords, Devices and Adapters provided as part of a System shall be guaranteed for the term of the Structured Cabling System Guarantee.
   1. Products shall be approved by the manufacturer of the cabling and connecting components used in the Structured Cabling Permanent Link and/or Backbone Cabling System(s).

PART 2 - PRODUCTS

2.1 4-PAIR MODULAR PATCH CORDS

A. Manufacturer: CommScope Systimax

B. 4-pair Modular Patch Panel Cords shall:
   1. Be part number 360GS10E-BL-3ft
   2. Be part number 360GS10E-WH-3ft
   3. Have modular plugs at both ends

C. 4-pair Modular Workstation Patch Cords shall:
   1. Be part number 360GS10E-BL-10ft
   2. Be part number 360GS10E-WH-10ft
   3. Have modular plugs at both ends

D. Patch Cord Modular Plugs shall be:
   1. 8-Position, 8-Conductor (8P8C)
   2. Pinned EIA/TIA T-568B
   3. Snagless Design

E. Dimensions of finished modular plug assembly shall allow for patch cords to be positioned in adjacent ports of Modular Patch Panel specified in Section 27 1100 - Communications Equipment Room Fittings.

F. Cable jacket material shall be PVC.

G. Where required by manufacturer's performance warranty, Patch Cords shall be by cabling or connecting component manufacturer whose products are installed under this project or by manufacturer recognized and approved by that manufacturer.
   1. Category 6A Patch Cords shall be channel balanced with Modular Jacks and Patch Panels specified in Section 27 1100 - Communications Equipment Room Fittings and Section 27 1500 - Communications Horizontal Cabling for use in Horizontal Cabling subsystem.

2.2 FIBER OPTIC PATCH CORDS - MULTIMODE

A. Manufacturers: CommScope Systimax

B. Multimode Fiber Optic Patch Cords shall:
   1. Be duplex LC-LC type
   2. Incorporate multimode optical fiber meeting specifications of backbone cabling in Section 27 1300 - Communications Backbone Cabling
   3. Have an AQUA cable jacket.

C. Patch cord channels shall be of equal length.

D. Channels shall be identified by strain-relief boot color or other means.

E. Duplex patch cords shall be configured so fiber position A connects to B and B connects to A per TIA/EIA-568.

F. Optical Connectors used in Patch Cords shall:
   1. Incorporate ceramic or glass-in-ceramic ferrules.
   2. Be standard PC (physical contact) style polished.
   3. Have connector bodies that are BEIGE in color.
   4. Incorporate strain relief at rear of connector body.

G. Patch Cord packaging shall include manufacturer’s quality control certification or test information.

2.3 FIBER OPTIC PATCH CORDS - SINGLE-MODE

A. Manufacturers: CommScope Systimax

B. Single-mode Fiber Optic Patch Cords shall:
   1. Be duplex LC-LC type.
   2. Incorporate single-mode optical fiber meeting specifications of backbone cable system in Section 27 1300 - Communications Backbone Cabling.
   3. Have YELLOW cable jacket.

C. Patch cord channels shall be of equal length.

D. Channels shall be identified by strain-relief boot color or other means.

E. Duplex patch cords shall be configured so fiber position A connects to B and B connects to A per TIA/EIA-568.

F. Optical Connectors used in Patch Cords shall:
   1. Incorporate ceramic or glass-in-ceramic ferrules.
   2. Have connector bodies that are BLUE in color.

3. Incorporate strain relief at rear of connector body.
4. Be UPC (ultra physical contact) style polished.

G. Patch Cord packaging shall include manufacturer's quality control certification or test information.

PART 3 - EXECUTION

3.1 GENERAL

A. Furnish loose and small detachable parts per Division 1 - General Requirements.

A. Contractor shall furnish:
1. All loose and small detachable parts furnished under this Contract to Laboratory.
2. Three copies of an itemized listing of all parts.
a. Laboratory shall sign listing to confirm receipt and return 2 copies.
b. Contractor shall retain 1 copy of receipt for their files and attach remaining copy in request for final payment for work.

3.2 QUANTITIES AND LENGTHS

A. Furnish 4-pair Modular Workstation Patch Cords as follows:
1. 10 feet, blue - quantity 1 per workspace area.
2. 10 feet, white - quantity 1 per workspace area.
3. Store workstation cables in corresponding telecommunications room.

B. Furnish 4-pair Modular Patch Panel Cords as follows:
1. 3 feet, blue or white – quantity 1 per installed patch panel jack.
2. Coordinate quantity of blue and white cords with Laboratory.
3. Coil patch cables at bottom of rack housing patch panels.

C. Furnish Duplex Multimode Fiber Optic Patch Cords as follows:
1. 10 feet - one patch cable per terminated cable.
2. Coil patch cables at bottom of fiber rack.

D. Furnish Duplex Single-mode Fiber Optic Patch Cords as follows:
1. 10 feet - one patch cable per terminated cable.
2. Coil patch cables at bottom of fiber rack.

End of Section

SECTION 28 31 13

ACCESS CONTROL

PART 1 - GENERAL

1.1 RELATED WORK

a. Section 26 00 00 - General Electrical Requirements

b. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables

c. Section 26 05 26 - Grounding and Bonding for Electrical Systems

d. Section 26 05 33 - Raceway and Boxes for Electrical Systems

e. Section 26 05 53 - Electrical Systems Identification

1.2 REFERENCE

A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 DESCRIPTION

A. The Work includes furnishing all labor, materials, tools and equipment, and documentation required for an extension of the existing campus Access Control System as specified in this Section. This scope of Work shall cover the requirements for the access control, alarm monitoring and integrated imaging system as specified.

B. The Access Control System shall include all devices necessary to constitute a completely coordinated extension of the existing campus system.

C. The existing System is modular in nature and permits expansion of both capacity and functionality through the addition of control panels, card readers and sensors.

D. The sub-control panel shall incorporate the necessary hardware to collect, transmit, and process alarm, tamper and trouble conditions, access requests and advisories in accordance with the security procedures of the facility.

E. UPS: All 120 volt systems shall be equipped with an Uninterruptible Power Supply (UPS) with software that detects the loss of AC and battery power and automatically performs a system shutdown prior to total battery power loss. The UPS shall be sized to operate the system for approximately 15 minutes without AC power.

F. Existing System Capabilities:

1. Database Management:

   a. The System shall create and maintain a master database of all cardholder records and all system activity for all connected points.

2. Audit Trail:

a. The System shall maintain an audit trail file of operator activity. Provide the ability to generate a report by operator, time and date, and type of activity (audit code). The System shall allow the operator to direct the audit trail report to screen, printer or file.

3. Input Point Monitoring:
   a. Collect and process status information from all monitored points.
4. Alarm Annunciation:
   a. Audibly and visually annunciate all alarm, tamper and trouble conditions and advisories.
5. Input Point Supervision:
   a. Electrically supervise all 2-state and 4-state input point circuits.
6. Reports:
   a. The system shall be equipped with a fully integrated, dynamic report writer module that shall have access to the database fields to allow users to create custom reports without the need for computer programming skills.
7. Passwords:
   a. The operator password function shall control which menu items and cardholder database fields that the individual operator may access.
8. Alarm Input Point Suppression:
   a. The System shall provide an alarm input point suppression facility such that the operator may define a time zone suppression period for each individual input point. Alarm conditions for suppressed input points shall not, be recorded or archived by the System, however, trouble conditions will be recorded.
9. Alarm Handling:
   a. Alarm handling portion of system shall provide dynamic color alarm graphic maps with the following functions:
      1). User definable graphic maps to depict input point conditions in SMS.
      2). Support importing of graphics produced with any graphic drawing program.
      3). Software shall be capable of storing a number of graphic maps. Quantity shall be limited by available hard disk storage space only.
   b. User definable alarm message/instructions name.
   c. User definable alarm message/instructions description. System shall provide ability to assign alarm message/instructions to each state of input point (>Open=, >Short=, >Alarm/Active=, and >Secure.=)
   d. Alarm input points: the System shall support up to 17,000 alarm input points.
   e. The System shall support both 2-state and 4-state alarm input point monitoring.
   f. Alarm priority: the System shall provide an alarm priority queue from 0-9.
   g. Alarm instruction display: the SMS shall provide a window with up to ten lines of user defined instructions, which shall tell the operator how to respond to a selected alarm.
10. Time Zones:
   a. The system shall provide the capability for the user to define time zones with the following identification and configuration parameters:
      1). Alphanumeric name.
      2). Alphanumeric description.
      3). Allowance for up to eight periods, four active and four inactive, during each day of the week and each of three different holiday types.
      4). Any number of days of the year may be designated as a holiday, each defined as one of three holiday types.

11. Communications:
    a. Communications between the Host computer and the sub-controllers shall be a redundant, bi-directional path such that loss of communications in one direction, caused by a single open or break, automatically causes communications to be established in the other direction without operator intervention.
    b. Should the sub-controller(s) lose communications with the Host, the sub-controllers shall continue to control access and monitor inputs for all connected points.
12. User Defined Cardholder Database Fields:
    a. System shall support up to 64 user defined data fields, which may be used to store information for each cardholder.
13. Event and Transaction History:
    a. maintain record of all alarm card transaction and system exceptions, which take place and provide means for user to access this information.
14. Anti-Passback Control:
    a. provide capability to prevent more than one person from gaining access to controlled area by recognizing when cardholder who is granted access is passing back the card to another person to use the same card to gain access.
15. Entry/Exit Control:
    a. provide the capability to control a card's entry into or exit from an area based on the card's previous transaction status.
16. Cardholder Definition:
    a. provide capability for user to define Cardholders with the following identification and operating parameters.
        1). Cardholder name (first, middle, last).
        2). Cardholder address.
        3). Cardholder phone number and extension number.
        4). Validation period using start and void dates.
        5). Department and Company fields from selection list of user defined departments and companies.
17. Alarm Monitoring and Output Control Terminal Boards:
    a. Intelligent alarm monitoring and output control terminal boards shall be plug-in modules to the sub-controller with the following functionality:
        1). Sixteen two-state alarm input points.
        2). Eight four-state supervised alarm input points.
        3). Eight two-state alarm input points and eight SPDT output relays.
        4). Eight four-state supervised alarm input points and eight SPDT output relays.
18. Badge Definition:
    a. provide capability for user to define Cardholders with the following Badge Identification and operating parameters on per badge basis:
        1). Badge number assignment
        2). Issue level (0-7), only (1) per badge
        3). Validation period using start and void date and time
        4). Globally active enable or disable
        5). Executive privilege enabled or disabled
        6). Active/Void badge toggle button
        7). Trace enabled or disabled

8). Override enabled or disabled

1.4 REFERENCE STANDARDS

A. UL 294 - Access Control System Units.

B. UL 1075 - Proprietary Burglar Alarm Units and Systems.

C. FCC Rules and Regulations Part 15, Radio Frequency Devices

D. NEMA 250 Enclosures for Electrical Equipment

1.5 SUBMITTALS

A. Submit Shop Drawings for equipment furnished under this Section.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. All access control hardware and software shall be as manufactured by DSX Access Systems Inc.

2.2 HARDWARE REQUIREMENTS

A. Cards and Card Readers:
1. General:
a. All readers shall be configured with reader electronics mounted separately, on "secure" side of the door such that only the reader head and pilot lights are mounted in the reader housing on the "entry" side of the door.

B. Proximity Type Technology Reader:
1. Standard range card reader
a. Reader shall be HID iClass RP40-Gray
b. Reader shall be integrated and contain all reader electronics inside single polycarbonate enclosure.
c. Reader shall operate when mounted on variety of surfaces including metal. Maximum read range degradation when mounted on metal surface shall be 50 percent.
d. Reader shall contain integral bi-color LED and audio tone to indicate if card has been successfully read.
e. Reader shall be 3.3” x 4.8” x .95” maximum.
f. Read range shall be up to 4.0 - 4.5”.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

A. All components shall be shipped to job-site in original manufacturer's shipping containers.

B. All equipment stored on the job site shall be secured in locked storage area as designated by General Contractor or ANL.

3.2 INSTALLATION REQUIREMENTS

A. Installation shall be coordinated with ANL Security installations Department

B. Each wire shall be identified at both ends with wire designation corresponding to wire numbers shown on wiring diagrams.

C. All exposed wiring within cabinets and terminals shall be formed neatly with wires grouped in bundles using non-metallic, flame-resistant wiring cleats or wire ties.

D. All ferrous metal work shall be painted in accordance with manufacturer's standards.

E. Where reader is mounted to metal provide spacer to maximize read range

3.3 TESTING AND COMMISSIONING

A. Contractor shall be responsible for testing and commissioning of installation.
   1. Testing shall be comprehensive and sufficient to demonstrate compliance with each requirement.
   2. Proposed test plan shall be submitted to ANL's representative for approval prior to commencement of final test.
   3. Final tests shall be conducted in presence of the ANL's representative.

B. Startup
   1. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

C. Functional Performance Tests
   1. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

3.4 WARRANTY

A. All equipment furnished under this contract shall be warranted for period of twelve (12) months from date of final ANL acceptance of system.

End of Section

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SECTION 28 31 16

MULTIPLEXED FIRE ALARM AND MASS NOTIFICATION SYSTEM

PART 1 - GENERAL

1.1 RELATED WORK

A. Section 14 24 00 - Hydraulic Elevators

B. Section 21 13 14 - Automatic Fire Sprinkler System

C. Section 23 09 93 - Control Sequences

D. Section 26 00 00 - General Electrical Requirements

E. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables

F. Section 26 05 26 - Grounding and Bonding for Electrical Systems

G. Section 26 05 33 - Raceway and Boxes for Electrical Systems

H. Section 26 05 53 - Electrical Systems Identification

1.2 REFERENCE

A. The Work under this Section is subject to requirements of the Contract Documents including the General Conditions, Supplementary Conditions, and sections under Division 01 General Requirements.

B. This section specifies a system or a component of a system being commissioned as defined in Section 01 91 00 Commissioning. Testing of these systems is required, in cooperation with the Laboratory and the Commissioning Authority. Refer to Section 01 91 00 Commissioning for detailed commissioning requirements.

1.3 DESCRIPTION

A. In general work consists of:
   1. Furnish and install complete Multiplexed Fire Alarm and Mass Notification System to integrate with the existing campus Honeywell EXCEL Building Integrator system.
   2. System shall:
      a. Be an intelligent analog system.
      b. Allow for loading and editing special instructions and operating sequences as required.
      c. Be capable of on-site programming to accommodate system expansion and facilitate changes in operation.
      d. Be wired, connected, and left in operating condition.
   3. System includes:
      a. Control Panel(s)
      b. Manual Stations
      c. Smoke Detectors
      d. Alarm Indicating Devices
      e. Speakers
      f. Terminations

g. Other necessary material for complete operating systems.

4. Software operations shall be stored in non-volatile programmable memory within fire alarm control panel. Loss of primary and secondary power shall not erase instructions stored in memory.

1.4 REFERENCE STANDARDS

A. IBC - 2000 International Building Code

B. IFC - 2000 International Fire Code

C. NECA 305 Standard for Fire Alarm System Job Practices

D. NFPA 72 National Fire Alarm Code

E. NFPA 101 Life Safety Code

F. UL 268 Smoke Detectors for Fire Protective Signaling Systems

G. UL 497B Protectors for Communications and Fire Alarm Circuits

H. UL 864 Control Units for Fire Protective Signaling Systems

I. UL 1481 Power Supplies for Fire Protective Signaling Systems

J. UL 1711 Amplifiers for Fire Protective Signaling Systems

1.5 QUALIFICATIONS

A. Equipment shall be supplied by company specializing in Fire Alarm and Smoke Detection systems with 5 years documented experience.

B. Work shall be performed by licensed Contractor regularly engaged in installation and servicing of Fire Alarm Systems.

C. Proof of 5 years documented experience and factory authorization to furnish and install equipment proposed shall be furnished.

D. Contractor shall be located within 100 miles or less from site of Project.

1.6 SUBMITTALS

A. Bill of materials listing part number and quantity of components and devices.

B. Block diagrams showing layout and operation of entire system.

C. Schematic diagrams, of circuits from field devices to terminal strip(s) associated with control panel.

1. Diagrams shall show schematic wiring of equipment; and connections to be made to devices.
2. Terminal connections in equipment shall be numbered to correspond to diagrams.
3. Wiring diagrams shall be coordinated so that terminal numbering, circuit designation and equipment or device designations are same on drawings.

D. Standby battery power calculations.

E. Sound amplifier and strobe power supply calculations showing current draws for every device and module during standby, alarm and trouble conditions.

F. Voltage drop calculations for both initiating and alarming circuits.

G. List of device addresses with location labeling as they will appear in 2-line, 40 character display of fire alarm panel.

H. Submission to Authority Having Jurisdiction (AHJ):
   1. Copy of shop drawings as required to show component locations.
   2. Upon receipt of comments from AHJ, make resubmissions if required to make clarifications or revisions to obtain approval.
   3. All fees associated with this shall be included in the Bid.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Siemens

2.2 SYSTEM OPERATIONS

A. Alarm Initiation
   1. System alarm operation after activation of any manual station, automatic detection device, or sprinkler flow switch shall be:
      a. Appropriate initiating device circuit red LED shall flash on Control Panel until the alarm has been acknowledged at Control Panel.
      b. Once acknowledged, this same LED shall latch on.
      c. Subsequent alarm received after acknowledging shall flash subsequent zone alarm LED on Control Panel.
      d. Acknowledgment of alarm shall not reset activated device.
      e. Visual alarm indicating devices shall operate in continuous flashing pattern until system is reset.
      f. Signal to notify the supervising station shall be activated.
      g. Mechanical controls shall activate air handling systems as specified by Division 23.
   2. System shall have single key to allow operator to display alarms, troubles, and supervisory service conditions including time and date of each occurrence.
   3. Alarm shall be displayed on an 80-character LCD display as follows:
      a. 40 characters for:
         1). Point address and loop number
         2). Type of device
         3). Point status
      b. 40 characters for:
         1). Custom location label

B. Silencing
   1. Alarm audible indicating devices shall be silenced by operating alarm silence switch.
   2. Strobes shall remain active until system is reset.
   3. Subsequent zone alarm shall reactivate alarm signals.

C. Reset
   1. SYSTEM RESET button shall return system to its normal state after an alarm condition has been remedied.

D. Supervision
   1. System shall independently supervise:
      a. Initiating device circuits.
      b. Sprinkler flow and tamper switches.
      c. Independently fused indicating appliance circuits for alarm horn/strobe units.
      d. Auxiliary manual controls. "Off normal" position of any switch shall cause an "off normal" system trouble.
      e. Auxiliary circuits for addressable relays. Blown fuse or open in circuit shall be visibly and audibly annunciated.
      f. Remote annunciator panel. Any ground, short, or open in the wiring to fire alarm Control Panel, as well as malfunction of the annunciator panel shall be annunciated at control panel.
      g. Incoming power. Power failure shall be audibly and visually indicated at Control Panel. Green "power on" LED shall be displayed continuously while incoming power is present.
      h. System Modules for module placement. Should modules become disconnected, system trouble indicator shall illuminate and audible trouble signal shall sound.
      i. System batteries. Low battery condition or disconnection of battery shall be audibly and visually indicated at Control Panel.
   2. Device activation shall be annunciated at Control Panel.
   3. Independently supervised circuits shall include visible amber "Trouble" LED to indicate disarrangement conditions per circuit.
   4. Disarrangement conditions of any circuit shall not affect operation of other circuits.
   5. Alarm activation of any initiation circuit shall not prevent subsequent alarm operation of any other initiation circuit.
   6. System shall have provisions for disabling and enabling circuits individually for maintenance or testing purposes.

E. Power Requirements
   1. Provide 120 VAC power via dedicated branch circuit.
   2. Branch circuit shall have "breaker lock" to prevent accidentally de-energizing of power to fire alarm panel.
   3. Circuit breaker shall be painted red and labeled "FIRE ALARM".
   4. Provide disconnect switch for AC power near panel or within Fire Alarm Control Panel itself. Switch shall be labeled “Fire Alarm Power Disconnect”.
   5. Provide power surge and transient protection.
   6. Provide back-up battery capacity, regulated 24VDC current, to supply entire system in full standby and evacuation load plus a @20% buffer.
   7. System shall automatically transfer to standby batteries upon power failure.
      a. Battery charging and recharging operations shall be automatic.
   8. Provide power limited, filtered and regulated battery charger.
      a. Charger shall:
         1). Be combination high rate/float maintenance type.
         2). Charge fully discharged battery to 70% in 12 hours.

3). Monitor for AC fail/disconnect, low/no battery, and high battery level.

4). Include switches and associated LEDs for high rate and AC disconnect.

5). Provide 5 amps of regulated 24VDC for peripheral devices requiring ± 5% regulation and 8 amps at 24VDC for standard peripheral devices.

6). Be compatible with lead acid batteries.

9. External circuits requiring system operating power shall be 24VDC and shall be individually supervised and fused at Control Panel.

F. Smoke Detection Operation

1. Smoke detector alarms shall be processed and reported immediately.
2. Upon building completion, alarm verification shall be added to detector(s) as directed by Project Engineer.
3. Control Panel shall:
   a. Be capable of displaying number of times (tally) detector has gone into verification mode from the system history.
   b. Download alarm set point to detector.
   c. Determine condition of each detector by comparing detector's value to stored values.
   d. Maintain moving average of detectors' smoke chamber value to automatically compensate for dust and dirty conditions.
   e. Continuously perform an automatic self-test routine on each detector.
   f. Have capability of being programmed for pre-alarm or two-stage function.
   g. Clear "detector dirty" trouble after detector has been removed from its base cleaned and replaced.
4. System shall maintain constant smoke obscuration sensitivity for each detector by compensating for environmental factors.
5. Photoelectric detector's smoke obscuration sensitivity shall be adjustable to within 0.3% of either limit of UL window (0.5% to 4.0%) to compensate for any environment.
6. System shall indicate when individual detector needs cleaning. When detector's average value reaches predetermined level, trouble MESSAGE shall be audible and visibly indicated at Control Panel. LED on detector base shall glow steady giving visible indication.
7. For scheduling of maintenance, Control Panel shall generate MESSAGE indication for any detector approaching trouble condition due to dirt or contamination.
8. Operator shall have capability to manually access the following information for each detector:
   a. Primary status.
   b. Device type.
   c. Present average value.
   d. Present sensitivity value selected.
   e. Detector range (normal, dirty, etc.).
9. Values at Control Panel shall be in "percent of smoke obscuration" format so that, no interpretation is required by operator.
10. Operator shall be able to manually control following for each detector:
    a. Enable or disable detector.
    b. Establish alarm sensitivity.
    c. Control detector's relay driver output.
11. It shall be possible to program Control Panel to automatically change sensitivity settings of each detector based on time-of-day and day-of-week. There shall be three (3) sensitivity settings available for each detector.

G. System Response
   1. Maximum elapsed time from sensing fire at non-smoke detector initiating device or second smoke detector until it is recorded at Control Panel shall not exceed 5 seconds and not to exceed 15 seconds for remote station reporting.

H. Air Handling Unit System Operation/Interface
   1. Control Panel shall provide alarm interface to air handling/energy management system controllers, which shall perform automatic functions as specified in Division 23.
   2. Fire Alarm Control Panel shall provide manual control mode to override fire alarm panel's signal so that air handling units can be restarted.

I. Sprinkler System Operation/Interface
   1. Activation of any standpipe or sprinkler system tamper or water flow switch shall activate system supervisory service audible signal and illuminate LED at Control Panel.
   2. Control Panel shall provide differentiation between switch operation and opens and/or grounds on initiation circuit wiring.
   3. Pressing acknowledge key will silence audible signal while maintaining supervisory service LED "on" indicating off-normal condition.
   4. Restoring valve to normal position shall cause supervisory service audible signal to pulse indicating restoration to normal position.
   5. Acknowledge key shall silence audible signal.

J. Manual Evacuation (Drill) Operation
   1. Manual evacuation (drill) switch shall be provided to operate alarm indicating appliances without causing other control circuits to be activated.
   2. Should true alarm occur, alarm functions would occur.

K. LED and LCD Test Operation
   1. Activation of Lamp Test switch shall turn on all LED indicators, LCD display, and the local sounder and then return to previous condition.

L. System Diagnosis
   1. System shall include special software to detect, diagnose and report failures and isolate such failures to printed circuit board level.

M. Watch-Dog Timers
   1. System shall include independent "Watch-Dog" timers to detect and report failure of any microprocessor circuit, memory, or software.

N. Mass Notification System Functions
   1. The notification appliance network consists of audio speakers located to provide intelligible instructions to all occupied areas as indicated on the drawings. The Mass Notification System announcements shall take priority over all other function of the system including the audible output of the fire alarm system in a normal or alarm state. All fire alarm system functions shall continue in an alarm state except for the output signals of the audible notification appliances. Fire alarm audible signals shall resume once the mass notification signals are disconnected and until the fire alarm condition is reset.

2.3 ENCLOSURE

A. Provide cabinets of sufficient size to accommodate equipment.

B. Cabinet shall be equipped with door, with lock and transparent door panel, providing tamper proof enclosure and allowing full view of various lights and controls.

2.4 CONTROL PANEL

A. Control Panel shall be modular, expandable with solid state, microprocessor based electronics.

B. Control panel shall have the capability of temporarily deactivate the fire alarm audible notification appliances while delivering voice messages. Control Panel shall provide the following features:

1. Secure operator console for initiating recorded messages, strobes and displays; and for delivering live voice messages
2. Capacity for the (5) five pre-recorded messages
3. Ability to automatically repeat pre-recorded messages
4. Secure microphone for delivering live messages
5. Support intelligent (analog) detection devices.
6. Number of initiating device loops required for specified quantity of initiating devices plus one (1) spare loop for each five (5) active loops. Each active loop shall include 5% spare capacity.
7. Number of indicating device (horn/speaker) circuits required for quantity of horns/speakers alarm, plus one (1) spare circuit for each ten (10) active circuits. Each active circuit shall include 25% spare capacity.
8. Number of indicating device (strobe) circuits required for specified quantity of strobes plus one (1) spare circuit for each ten- (10) active circuits. Each active circuit shall include 25% spare capacity.
9. 80-character liquid crystal display
10. Printer interface
11. History log file with minimum of 600 events
12. Field programmable
13. Drift compensation
14. Sensitivity display in %
15. Sensitivity adjustment
16. Day/night sensitivity adjustment
17. Auto detector test
18. Silent walk test
19. Maintenance alerts

C. System shall provide ability to recall alarms and trouble conditions in chronological order.

D. Under normal condition viewing window shall display "System is Normal" message and current time and date.

E. When an abnormal condition occurs appropriate LED (Alarm, Supervisory or Trouble) shall flash.

F. Audible signal shall pulse for alarm conditions and sound steady for trouble and supervisory conditions.

G. Panel shall display the following information relative to abnormal condition of a point in system prior to acknowledgement:

1. 40 characters for:
   a. Point address and loop number
   b. Type of device (i.e. smoke, pull station, water-flow)
   c. Point status (i.e. alarm, trouble)

2. 40 characters for:
   a. Custom location label (i.e. 4th Floor - Room 444)

H. Keyboards or keypads shall not be required to operate the system during fire alarm conditions.

I. Following software functions shall be provided:
1. Setting of time and date
2. LED testing
3. Alarm, trouble, and abnormal condition listing
4. Enabling and disabling of each monitor point separately
5. Activation and deactivation of each control point separately
6. Changing operator access levels
7. Walk Test enable
8. Running diagnostic functions
9. Displaying historical logs
10. Point listing

J. Following hardware functions shall be provided:
1. Acknowledge alarm or trouble
2. Silence alarm or trouble
3. Reset system after alarm
4. Connect/disconnect Supervising station tie
5. Provide manual evacuation (drill)
6. Bypass elevator recall and shunt trip operation
7. Bypass door holders
8. Allow computer interface

2.5 STATUS INDICATORS AND DISPLAYS

A. Audible device shall sound during Alarm, Trouble or Supervisory conditions.

B. Audible device shall sound during each key-press.

C. Visual display shall distinguish between alarm, trouble and supervisory conditions.

D. Indicators and displays to be visible:
1. One red system alarm LED
2. One yellow supervisory service LED
3. One yellow trouble LED
4. Green "power on" LED
5. Eighty-character LCD

E. 2-line by 40-character LCD shall be backlit.

F. Cursor shall be visible on LCD when entering information.

G. Scrolling through menu options shall be in self-directing manner in which prompting messages shall direct user.

H. Controls shall be located behind an access door.

I. Status data to be available on display:
   1. Initiating device circuits
   2. Indicating device circuits
   3. Auxiliary relays
   4. Primary State of point
   5. Zone information
   6. Class "A" Status
   7. Current priority of outputs
   8. Disable/Enable status
   9. Automatic/Manual Control Status of output points
   10. Acknowledge status

2.6 CONTROLS

A. Controls (one switch per function per system) visible through front viewing window:
   1. Alarm Acknowledge key
   2. Trouble Acknowledge key
   3. Alarm Silence key
   4. System Reset key

B. Controls accessible with front door open:
   1. Supervising station disconnect/switch
   2. Manual evacuation (drill)
   3. Fan shut down override/bypass switches
   4. Key pad for data input and microprocessor control

2.7 LED SUPERVISION

A. Slave module LEDs shall be supervised. When problem occurs LCD shall display module and LED location.

2.8 VOICE NOTIFICATION SYSTEM

A. The Voice Notification System shall comply with the requirements of NFPA 72 for Emergency Voice/Alarm Communications System requirements IEC 60849, IEC 60268-16, except as specified herein. The system shall be a one-way multi-channel voice notification system incorporating user selectability of a minimum 8 distinct sounds for tone signaling, and the incorporation of a voice module for delivery of prerecorded messages. Textual audible appliances shall produce a slow whoop tone for three cycles followed by a voice message that is repeated until the control panel is reset or silenced. Automatic fire alarm messages shall be broadcast through speakers on all floors in all zones, but not in stairs or elevator cabs. Speakers in stairs and elevator cabs shall be arranged for live voice paging only. A live voice message shall override the automatic audible output through use of a microphone input at the control panel. When using the microphone, live messages shall be broadcast through speakers in stairs, in elevator cabs, and throughout a selected floor or floors. The system shall be capable of operating all speakers at the same time. The digitalized voice message shall consist of a non-volatile (EPROM) microprocessor based input to the amplifiers. The microprocessor shall actively interrogate circuitry, field wiring, and digital coding necessary for the immediate and accurate rebroadcasting of the stored voice data into the appropriate amplifier input. Loss of operating power, supervisory power, or any other malfunction that could render the digitalized voice module inoperative shall automatically cause the slow whoop tone to take over all functions assigned to the failed unit. The Mass Notification functions shall override the manual or automatic fire alarm notification or Public Address (PA) functions. The system shall have the capability of utilizing a remote microphone station with

redundant controls of the notification system control panel. Class "A" Notification Appliance Circuits (NAC) shall be provided for the activation of strobe appliances. The activation of the NAC Circuits shall follow the operation of the speaker NAC circuits. Audio output shall be selectable for line level (600 ohms), 25, 70.7 or 100 volt output. The audio amplifier outputs shall be not greater than 100 watts RMS output. The strobe NAC Circuits shall provide at least 2 amps of 24 VDC power to operate strobes and have the ability to synchronize all strobes. A hand held microphone shall be provided and, upon activation, shall take priority over any tone signal, recorded message or PA microphone operation in progress, while maintaining the strobe NAC Circuits activation. All outputs and operational modules shall be fully supervised with on-board diagnostics and trouble reporting circuits. Form "C" contacts shall be provided for system alarm and trouble conditions. Circuits shall be provided for operation of auxiliary appliance during trouble conditions. During a Mass Notification event the panel shall not generate nor cause any trouble alarms to be generated with the Fire Alarm system. The system shall be housed in a separate panel that contains an independent power supply and batteries, as specified above. Mass Notification functions shall take precedence over all other function performed by the Voice Notification System. Messages shall utilize a female voice and shall be similar to the following:

1. Exact wording of pre-recorded messages shall be directed by the Laboratory.
2. 21000 Hz tones (1 sec on, 1/2 second off, 1 second on, 1/2 second off, 1 second on)
   a. "May I have your attention please. May I have your attention please. A fire emergency has been reported in the building. Please leave the building by the nearest exit or exit stairway. Do not use the elevators." (Provide a 2 second pause.) "May I have your attention please..(repeat the message)."
3. 1000 Hz tones (1 sec on, 1/2 second off, 1 second on, 1/2 second off, 1 second on)
   a. "Alert! This is the Mass Notification System. There is an emergency situation. DO NOT evacuate the building! Stay in your current location! Stay tuned for further instructions."
   b. (repeat message 2 times)
4. 1000 Hz tones (1 sec on, 1/2 second off, 1 second on, 1/2 second off, 1 second on)
   a. "Alert, This is the Mass Notification System. There is a chemical gas emergency. Turn off all HVAC equipment, seal all doors and windows with wet fabric, Don protective gear. DO NOT evacuate the building, Act now! Listen to the MNS system for further instructions".
   b. (repeat message 2 times)
5. 1000 Hz tones (1 sec on, 1/2 second off, 1 second on, 1/2 second off, 1 second on)
   a. "Alert, this is the Mass Notification System. There is a explosive blast risk along the South wall of your building. Quietly move towards the north side of the building, and exit from the north stairs. Move away from the building heading south to the south parking area.
   b. (repeat message 2 times).

B. The Remote Microphone station shall incorporate a Push-To-Talk (PTT) microphone, redundant controls and system status indicators of/for the system. The unit shall incorporate microphone override of any tone generation or prerecorded messages. The unit shall be fully supervised from the control panel. The housing shall contain a lock that is keyed identical to the fire alarm system for the building.

2.9 AUXILIARY INPUT MODULE SHALL BE DESIGNED TO BE AN OUTBOARD EXPANSION MODULE TO EITHER EXPAND THE NUMBER OF OPTIONAL REMOTE MICROPHONE STATIONS, OR ALLOW A TELEPHONE INTERFACE.ACKNOWLEDGMENT

A. Two methods of acknowledgment for each abnormal condition shall be provided:
   1. Acknowledge one event at a time from an unacknowledged list of events.
   2. Pressing acknowledge button shall display first unacknowledged condition in list (either alarm, supervisory or trouble), and require another acknowledge button. Press to acknowledge only displayed point.

B. After all points have been acknowledged, LEDs shall glow steadily and alarm will be silenced. Total number of alarms, supervisory and trouble conditions shall be displayed.

C. Pressing appropriate acknowledge button shall acknowledge all points

D. Acknowledge functions shall be behind locked door or pass-code protected.

2.10 SILENCING

A. If an alarm condition exists and "Alarm Silence" button is pressed, all alarm signals shall cease operation. Strobes shall remain active until system is reset.

B. If trouble conditions exist in system and "Trouble Silence" button has been pressed, audible trouble signal shall cease, but shall resound at timed intervals to act as reminder that fire alarm system is not in normal operating mode.

2.11 RESET

A. SYSTEM RESET button shall be used to return system to normal state after alarm condition has been remedied.

B. Should an alarm condition continue to exist, system shall provide indications that resetting cannot be completed and shall remain in an abnormal state.

C. Sonalert and Alarm LED shall remain activated.

D. Display shall indicate total number of alarms and troubles present in system along with prompt to use ACK keys to review points.

E. Points shall not require acknowledgment if they were previously acknowledged.

F. Should Alarm Silence Inhibit function be active, system shall ignore all key presses. An indication of enabling and disabling inhibit state shall be provided as feedback to operator.

2.12 ACCESS LEVELS

A. Provide four (4) access levels with Level 4 being highest level. Level 1 Actions shall not require pass-code.

B. Pass-codes shall consist of up to five (5) digits.

C. Pass-code digits entered shall be displayed as an X to indicate that digit has been accepted.

D. Key presses shall be acknowledged by local audible sound.

E. When correct pass-code is entered, system shall indicate to operator "*Access Granted*".

F. Access level shall be in effect until operator manually logs out or keypad has been inactive for five (5) minutes.

G. Operator entering invalid code shall be notified with message, *"Incorrect Pass- Code*", and shall be allowed three chances to enter valid code. After three unsuccessful tries, the message, "*Access Denied*", shall be displayed.

H. Following keys/switches shall have associated access levels:
   1. Alarm Silence
   2. System Reset

3. Set Time/Date
4. Manual Control
5. On/Off/Auto Control
6. Disable/Enable
7. Programming functions
8. Clear Historical Alarm Log
9. Clear Historical Trouble Log
10. Walk Test

I. Acknowledge keys shall require pass code access to acknowledge points. If operator presses an (ACK) key with insufficient access, an error message shall be displayed.

2.13 POINT LISTING

A. Point list menu includes:
1. All points list by address
2. Monitor point list
3. Signal/speaker list
4. Auxiliary control list
5. Feedback point list

2.14 HISTORY LOGGING

A. System shall be capable of logging and storing the last 400 events (alarm & trouble) in history log. These events shall be stored in battery protected random access memory.

B. Following historical alarm log events shall be stored:
1. Alarms
2. Alarm Acknowledgment
3. Alarm Silence
4. System Reset
5. Alarm Historical log cleared

C. Following historical trouble log events shall be stored:
1. Trouble conditions
2. Supervisory alarms
3. Trouble acknowledgment
4. Supervisory acknowledgment
5. Walk Test results
6. Trouble Historical log cleared

2.15 COMPUTER INTERFACE

A. Control Panel shall operate as proprietary local system with capability of sending status data to and receiving control data from Laboratory Honeywell EXCEL Buildings Integrator (EBI) R310 central station.

B. CPU shall monitor all alarms and troubles and control selected functions of Control Panel.

C. CPU shall supervise all data communication wiring between CPU and Control Panel for opens, shorts and grounds.

2.16 FIELD PROGRAMMING

A. System shall be fully programmable, configurable, and expandable in field and shall not require replacement of memory IC's.

B. Programming may be accomplished through Control Panel keyboard or keyboard at printer, or use of PC.

C. Programs shall be stored in non-volatile memory.

D. Programming or reprogramming shall be done by supplier at no charge until system is accepted by ANL.

2.17 TERMINAL/PRINTER INTERFACE

A. Control Panel shall be capable of operating remote monitors and/or printers.

B. Output shall be ASCII from RS-232-C connection with an adjustable baud rate.

C. Each RS-232-C port shall be capable of supporting and supervising up to 4 remote CRTs and Printers.

D. Data amplifiers shall be used to increase CRT or printer line distance.

2.18 INTELLIGENT NETWORK

A. System shall provide communications with intelligent initiating and control devices individually.

B. Devices shall be individually annunciated at control panel.

C. Annunciation shall include the following conditions for each point:
   1. Alarm
   2. Trouble
   3. Open
   4. Short
   5. Device missing/failed

D. Devices shall have capability of being disabled or enabled individually.

E. There shall be no limit to number of detectors, stations, or addressable modules, which may be activated or "in alarm" simultaneously.

F. Multiple intelligent devices shall be connected to a single pair of wires.

G. Communication format must be completely digital poll/response protocol to allow t-tapping of circuit wiring.

2.19 MULTIPLEXED PERIPHERAL DEVICES

A. Devices shall be supervised for trouble conditions.

B. Failure of device shall not hinder operation of other system devices.

C. Device Identification
   1. Each intelligent device shall be identified by an address code.
   2. Location of end-of-line device shall be indicated on device that containing same.
   3. System must verify that proper type device is in place and matches software configuration.

D. Intelligent Detector Bases

1. Either base or head shall contain electronic circuits that communicate detector's status (normal, alarm, sensitivity status, trouble.) to Control Panel over two wires. Same two wires shall also provide power to base and detector.
2. Contacts between base and head shall be of bifurcated type using spring-type, self-wiping contacts.
3. Base shall have locking capability. Locking feature must be field removable when not required.
4. Upon removal of detector's head, trouble signal shall be transmitted to Control Panel.
5. Detector base or head shall contain LED(s), which shall flash when detector is being scanned by Control Panel.
6. LED(s) shall turn on steady when detector is in alarm condition.

E. Intelligent Detector Heads - General
1. Intelligent detector heads shall be low-profile type.
2. Heads shall be plug-in units, which mount to common base.
3. Heads shall be 24VDC type.
4. Heads may be reset by actuating Control Panel reset switch.
5. To minimize false alarms, voltage and RF transient suppression techniques shall be employed.
6. Smoke detectors shall:
   a. Be listed for sensitivity testing from Control Panel. Sensitivity test results shall be logged and downloaded to printer.
   b. Include an insect screen.
   c. Communicate actual smoke chamber values to Control Panel.
   d. Be covered with plastic bags after installation to maintain cleanliness. Bags shall be red for quick visual identification for removal at time of occupancy.

F. Intelligent Photoelectric Smoke Detectors
1. Detectors shall:
   a. Contain no radioactive material
   b. Be of solid state photoelectric type and shall operate on light scattering photodiode principle using pulsed infrared LED light.

G. Intelligent Duct Smoke Detectors
1. Duct detectors shall be of photoelectric ionization type.
2. Detectors shall be rated for air velocity to be expected.
3. It shall be possible to alarm duct detector by using remote or local test switch.
4. It shall be possible to clean sampling tubes by access through duct housings front cover.
5. Provide relays adjacent to motor controller, and remote keyed test switch and alarm LED indicator.

H. Manual Stations
1. Manual stations shall:
   a. Be single action
   b. Be constructed of high impact, red Lexan with raised white lettering and smooth high gloss finish.
   c. Contain circuits that communicate station's status (alarm, normal) to Control Panel over two wires.
   d. Mechanically latch upon operation and remain so until manually reset. Stations, which use Allen wrenches or special tools to reset shall not be accepted.
   e. Be fitted with screw terminals for field wire attachment.
2. Address shall be field programmable on station.

I. Interface Modules - General
   1. Interface Modules shall:
      a. Receive 24VDC power from separate two wire circuit.
      b. Be available in either Class B or Class A supervision version.
      c. Be supervised and identified by Control Panel.
      d. Be capable of being programmed for its "address" location.
      e. Be compatible with addressable manual stations and intelligent detectors on same intelligent initiating circuit.
   2. Class A wiring shall be looped back and connected to module.
   3. Class B wiring shall be supervised by an end-of-line device.
   4. Should interface module become non-operational or removed, trouble signal shall be transmitted to Control Panel.
   5. Interface module LED's shall be clearly visible on the face of the trim plate.

J. Interface Modules - Supervised Control
   1. Interface Modules shall be used for control of indicating appliances and AHU systems.
   2. Interface modules shall:
      a. Communicate supervised wiring status (normal, trouble) to fire alarm control panel.
      b. Receive from fire alarm control panel command to transfer relay.

K. Interface Modules - Supervised Monitoring
   1. Interface Modules shall:
      a. Be suited for monitoring of water-flow, valve tamper, and non-intelligent detectors.
      b. Addressable interface module shall be provided for interfacing normally open direct-contact devices to an intelligent initiating circuit.
      c. Provide power to and monitor status of zone consisting of conventional 2-wire smoke detectors and N/O contact devices.
      d. Communicate zone's status (normal, alarm, trouble) to Control Panel.
   2. Supervision of zone wiring shall be Class B or Class A.

L. Interface Modules - Non-Supervised Control
   1. Interface module shall provide double-pole/double-throw relay switching for loads up to 120VAC. It shall contain 2 amp fuses, one on each common leg of relay.

M. /STROBE UNITS
   1. Strobes shall be:
   2. Multi tap units with taps at 15, 30, 75 and 110 cd.
   3. Tapped at 15 candela peak power or as noted on drawings.
   4. In compliance with ADA requirements.
   5. On separate supervised circuit from horn circuit.
   6. Synchronized so strobes units within sight of each other flash simultaneously.
   7. Fire Alarm strobe cover plate shall be White labeled "FIRE" in red lettering with clear lens.
   8. Mass Notification strobe cover plate shall be White labeled "ALERT" in red lettering with amber lens.
   9. Strobe circuit loading shall be calculated at 75 cd tap for all devices.

N. Fire Alarm/Mass Notification Speakers

1. Audible appliances shall conform to the applicable requirements of UL 464. Appliances shall be connected into notification appliance circuits. Audible appliances shall generate a unique audible sound from other devices provided in the building and surrounding area. Surface mounted audible appliances shall be painted white . Recessed audible appliances shall be installed with a grill that is painted white.
2. Speakers shall conform to the applicable requirements of UL 1480. Speakers shall have six different sound output levels and operate with audio line input levels of 100 Vac, 70 Vac, 7 Vac, and 25 Vac, by means of selectable tap settings. Tap settings shall include taps of 1/4, 1/2, 1, 2, and 8 watt. Speakers shall incorporate a high efficiency speaker for maximum output at minimum power across a frequency range of 400Hz to 4000Hz, and shall have a sealed back construction. Speakers shall be capable of installation on standard 4 inch square electrical boxes. Where speakers and strobes are provided in the same location, they may be combined into a single unit. All inputs shall be polarized for compatibility with standard reverse polarity supervision of circuit wiring.
3. Provide speaker mounting plates constructed of cold rolled steel having a minimum thickness of 16 gauge and equipped with mounting holes and other openings as needed for a complete installation. Fabrication marks and holes shall be ground and finished to provide a smooth and neat appearance for each plate. Each plate shall be primed and painted.

2.20 CONVENTIONAL PERIPHERAL DEVICES

A. Sprinkler Waterflow Switches - Wet Systems
1. To be furnished and installed by Fire Protection Contractor under Division 21.
2. To prevent false alarms, flow switch shall incorporate adjustable time delay mechanism between the paddle-operated stem and alarm initiating contacts.
3. Tapped 1/2" conduit connection.

B. Sprinkler Valve Tamper Switches - Wet Systems
1. Sprinkler valve tamper switches shall be furnished and installed by Fire Protection Contractor under Division 21.
2. Switch shall be provided with either 1 or 2 sets of S.P.D.T. micro switches as required.

C. Fault Isolator Module
1. Provide Fault Isolator Module (FIM) on initiating device circuits in following situations:
   a. Loop extends to another floor.
   b. Loop extends to another building.
   c. For each 25 devices on a loop.
2. Fault Isolator Module shall:
   a. Automatically re-connect isolated section of loop upon correction of fault conditions.
   b. Not require any address setting.
   c. Operations shall be totally automatic. It shall not be necessary to replace or reset FIM after its normal operation.
   d. Include LED, which shall flash under normal operation and illuminate steady to indicate short circuit.

PART 3 - EXECUTION

3.1 GENERAL

A. Class B circuiting shall be used.

B. Installation shall be done in neat, workmanlike manner in accordance with manufacturer's recommendations.

C. Smoke detectors shall not be mounted until construction is completed.

3.2 RACEWAYS

A. Fire Alarm Panel risers shall be in conduit system separate from other building wiring.

B. Wiring shall be in conduit system separate from other building wiring. See Section 26 05 33 Raceway and Boxes for Electrical Systems.

C. Minimum 3/4" steel raceway.

D. Contractor shall size conduit and boxes by circular mil size of cable in conduit or box.

3.3 CONDUCTORS

A. Cables and wires shall be provided per manufacturer shop drawings.

B. Conductors shall be color-coded. Coding shall be consistent throughout facility.

C. Green wire shall be used only for equipment ground.

D. Control Panel power wiring shall be #12 AWG.

E. Control Panel shall have #12 AWG equipment ground wire.

F. Where fire alarm circuits enter or leave building, additional transient 75 to 90 volt gas tube protection shall be provided for each conductor.

G. Cable Detector Loops shall be twisted pair with shield jacket. Shield shall be connected to earth ground only at control panel.

H. Detector wiring shall not be in same conduit with 120/240 VAC wiring or other high current circuits.

I. T-taps or branch circuit connections allowed for class B intelligent loop circuits.

J. Leave 8" wire tails at each device box and 36" wire tails at Control Panel.

K. Wiring of initiating device circuits, alarm horn circuits, and alarm strobe circuits shall be #14 AWG minimum.

L. Fire alarm cable shall be held in place at device box, by means of 2-screw connector, (do not use squeeze or crimp type connectors).

M. Splices or connections shall be made within approved junction boxes and with approved fittings.

N. Boxes shall be red and labeled "FIRE ALARM SYSTEM" by decal or other approved markings.

O. Horn and strobe circuits shall have separate conductors, and shall operate independently of each other.

3.4 DEVICE MOUNTING

A. Recommended mounting heights, and requirements are as follows:
   1. Fire Alarm Control Panels
      a. Mount control panel so visual indicators and controls at 60" above floor level.
   2. Audio-Visual Devices

a. Install flush, semi-flush or surface mount 6" below finished ceiling or 80" from bottom of device to finished floor.
b. No devices protruding 4" or more shall be installed lower than 80".
c. Audio/visual devices may be installed on the ceilings in accordance with NFPA 72 - Table 2-A.
d. For surface mounting, use manufacture-supplied backboxes and trim plates.
e. Mark each device with its circuit number.

3. Manual Stations
   a. Manual stations shall be in unobstructed locations.
   b. For surface mounting, use manufacturers supplied backboxes and trim plates.
   c. Mark unit’s address on inside and outside of housing.

3.5 IDENTIFICATION LABELS

A. Junction boxes shall be painted red and labeled "Fire Alarm".

B. Circuits must be labeled with name of circuit and area being served by circuit.

C. Labels shall be permanent, and be machine generated. NO HANDWRITTEN OR NON-PERMANENT LABELS SHALL BE ALLOWED.

D. Labels shall be self-laminating, white/transparent vinyl and be wrapped around cable .

E. Flag type labels are not allowed.

F. Labels shall be of adequate size to accommodate circumference of cable being labeled and properly self-laminate over full extent of printed area of label.

G. Adhesive type labels not permitted except for phase and wire identification.

H. Wiring color code shall be maintained throughout installation.

I. Green wire shall be used only for equipment ground.

3.6 MANUFACTURER'S SERVICES

A. Supervision of installation shall be provided by trained service technician from manufacturer of fire alarm equipment.

B. Technician shall be US certified and have had minimum of 2 years of service experience in fire alarm industry.

C. Technician's name shall appear on equipment submittals and letter of certification from fire alarm manufacturer shall be sent to Project Engineer.

D. Manufacturer's service technician shall be responsible for following items:
   1. Pre-installation visit to job site to review equipment submittals and verify method by which system shall be wired.
   2. Make periodic job site visits to verify installation and wiring of system.
   3. Upon completion of wiring, final connections shall be made under supervision of technician.
   4. At time of final checkout, technician shall give operational instructions to ANL and/or his/her representative.
   5. Job site visits shall be dated and documented in writing and signed by Electrical Contractor.

6. Discrepancy shall be noted on document and copy kept in system job folder, which shall be available to Project Engineer any time during Project.

3.7 TESTING

A. Manufacturer's authorized representative shall perform complete functional test of each system and submit written report to Contractor attesting to proper operation of completed system prior to final inspection.

B. Contractor shall test each device in system before system is considered substantially complete.

C. Completed Fire Alarm System shall be fully tested by Contractor in presence of the ANL's representative and local Fire Marshal.

D. Upon completion of successful test, Contractor shall:
   1. Certify system to ANL in writing.
   2. Complete NFPA 1-7.2.1 record of completion form.
   3. Provide as-builts and O&M manuals.

E. Startup
   1. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 91 00 Commissioning.

F. Functional Performance Tests
   1. System functional performance testing is part of the Commissioning Process as specified in Section 01 91 00. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

3.8 WARRANTY

A. Contractor shall warrant completed fire alarm system wiring and equipment to be free from inherent mechanical and electrical defects for a period of 2 years from the date of substantial completion of Project.

B. Contractor shall post warranty period along with company’s name and telephone number inside fire alarm panel.

C. Warranty service for equipment shall be provided by system supplier's factory trained representative.

D. Warranty shall include parts, labor and necessary travel.

E. Occupied facility shall not be without UL and NFPA approved and fully operational fire alarm system for period longer than 2 hours. Emergency response shall be provided within 2 hours of notification, to contractor, of failure of system to perform operationally per UL and NFPA Standards.

F. Non-emergency service calls shall be responded to within 24 hours of notification to Contractor.

G. Repairs and/or replacement shall be completed within 72 hours of time of notification. Other than emergency, actual repairs and /or replacement shall be provided during normal working hours, Monday through Friday, excluding holidays.

H. If repair and/or replacement cannot be made within prescribed time, other means and methods of protection shall be provided to insure safety of building occupants during which time system is not in compliance with standards. This may involve up to and include hiring ANL approved qualified personnel to stand fire watch, at Contractor's expense.

3.9 TRAINING

A. Contractor shall provide minimum of 4 hours system operation training for ANL, Architect/Engineer, and Fire Department personnel.

B. Training session shall be at a time to be stipulated by the ANL.

C. Training shall be completed prior to final inspection.

3.10 MAINTENANCE CONTRACT

A. Equipment manufacturer shall make available to ANL, maintenance Contract proposal to provide minimum of 2 inspections and tests per year in compliance with NFPA-72 Codes.

3.11 SPARE PARTS

A. Contractor shall provide the following spare parts in quantities shown, with a minimum of 1/item:

Quantity	Type of Device Present
10%	Monitor Modules
10%	Control Modules
1%	Duct detectors with housing and sample tubes
1%	Horn/strobe Units
1%	Strobes
1%	Manual Stations

End of Section

SECTION 31 10 10

LANDSCAPE SITE PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Protection of existing campus landscape, trees, planting, soil areas to remain, within the project area, including monitoring, maintenance of landscape protection fences, as shown and specified.

B. Related Sections:
   1. Earthwork, Section 31 20 00
   2. Demolition, Section 31 10 00
   3. Soil Preparation, Section 32 91 00

1.2 SUBMITTALS

A. Provide landscape schedule as part of project schedule. List site work activities, with dates for landscape protection installation, tree removals, pruning, periodic arborist inspection, and maintenance of specified protection and estimated end of protection period. Receive approval from Owner for schedule prior to start of work.

B. Submit qualifications of Certified Landscape Technician (CLT), and Certified Arborist to be contracted for this work for Laboratory's approval.

C. Submit product information for materials to be used in protection, including and not limited to flagging tape, temporary fencing and stakes, signs, burlap, gator bags.

D. Submit Landscape Protection Shop Drawing, indicating areas to be maintained as part of contract for review during Preconstruction Landscape Inspection.

E. Submit as part of project record a monthly maintenance log recording site conditions and protection fence maintenance.

F. Submit response to landscape protection violations within 24 hour period.

G. Preconstruction Conference: Conduct preconstruction conference at the project site in compliance with requirements of Division 1 Section "Project Management and Coordination:
   1. Review maintenance procedures for trees to be protected.
   2. Review procedures for work on public property.
   3. Review plant protection locations and procedures for adjustment.

1.3 QUALITY ASSURANCE

A. Qualifications of Contractor: Work under this section must be actively directed and monitored by Certified Arborist, engaged by the Contractor, with a minimum of 5 years experience successfully completing projects of a similar size and value. All tree pruning must be performed by a Certified Arborist.
   1. Certified Arborist must be certified by the International Society of Arboriculture, licensed in the Chicago region, and experienced with landscape soil, tree protection, and trimming work for this locale.
   2. Arborist must be retained by Contractor as part of contract.

B. REVIEW OF SCHEDULE
   1. Review the project landscape schedule at the beginning of project and notify the Owner's Representative of pruning/landscape schedule conflicts with sound arboricultural and horticultural practices. Assist with schedule resolution which fulfills landscape protection objectives.

C. LANDSCAPE PROTECTION PENALTIES
   1. Protect all landscape to remain, within and outside of the project limit, through management of construction staff, site fencing, monitoring, to prevent damage to soil and plantings by construction activities. Use of non-designated locations without the Laboratory's Representative written direction will result in a $500 per incident per day fine, in addition to correction of damage including mechanical decompaction of soil, sod and landscape replacement, hardscape, drainage repair.
   2. Removal or Damage to protected plants, as determined by Laboratory caused by the direct negligence of the Contractor, to be compensated to Laboratory at the rate of $250 per caliper inch, in addition to correction of damage through tree and planting replacement.
   3. Coordinate work of other disciplines, to protect landscape areas from damage.
   4. Respond to Laboratory's Representative direction to correct Protection deficiencies. Following a 24 hour failure to respond, the Commissioner may correct the deficiencies and the cost thereof will be deducted from monies due or which may become due the Contractor. This corrective action will in no way relieve the Contractor of his/her contractual requirements or responsibilities.
   5. Where landscape areas or trees are damaged by the Contractor's operation or personnel, the Contractor shall be responsible for repair or remediation of the damage as determined by the Laboratory's Representative.
      a. In the event that the damage to the tree is beyond repair and requires removal or the Contractor mistakenly removed the tree, the tree must be replaced by a 3 ½ " tree, B/B, designated by the Laboratory's Representative at the Contractor's expense, and carrying a one year replacement guarantee, in addition to incurred fines.
   6. The quality of the replacement tree must meet ANSI Z60.1 standards for size, variety, and species, and carry a replacement warranty which extends 12 months beyond the end of the contract period.
   7. Landscape damage resulting in soil compaction or grade changes in protection areas will subject the Contractor to perform vertical mulching and/or radial aeration as directed by the Laboratory's representative.
   8. Replacement and Damages:
      a. Decisions of Laboratory's Representative for required repairs and

replacement shall be conclusive and binding upon Contractor.

b. The Contractor is responsible for repairing damage to property also caused by defective workmanship and materials.

PART 2 - PRODUCTS

2.1 PROTECTION MATERIALS

A. Water:
1. Verify with Laboratory that water supply is available. Coordinate with Laboratory's Representative as needed. Provide hose and equipment necessary for proper watering of plant material. Provide water at no extra cost if it is not available at the project site.

B. Miscellaneous Materials:
1. Submit Product Information and receive Laboratory's Representative approval prior to use.

PART 3 - EXECUTION

3.1 LANDSCAPE PROTECTION

A. Include Landscape Protection Activities, reviews on General Project Schedule as part of work. Notify Laboratory's Representative of review meetings one week minimum in advance.

B. Prior to beginning work, field stake routing for proposed utility routing for review by Contractors, Laboratory, A/E, and Certified Arborist. Certified Arborist shall input on revised routing if root zones or canopy will be compromised by proposed routing and provide routing for review by Laboratory.

C. Prior to beginning work, the Contractor must have all tree protection measures in place and pass a Preconstruction Landscape Inspection, during which the Contractor and Certified Arborist must review with Laboratory's Representative individual plants to be protected, protection measures in place as indicated, schedule, landscape protection, tree removal, pruning, activities, soil stockpiling, and other landscape protection related activities.

D. Protect designated trees as shown on the plans or as directed by the Laboratory's Representative. Mark protected trees with surveyor flagging tape placed around the trunk at eye level.

E. Provide signage and monitor as needed to prevent access into protection areas, including vehicle traffic and storage of materials or equipment. Retain monthly inspection log, recording condition of protection areas, protection maintenance and repairs.

F. Provide temporary orange snow fencing at the drip line (outer edge of tree canopy) of all trees designated for protection, and as shown on the plans or as directed by the

Laboratory's Representative. Securely fasten fencing to posts spaced a maximum of five (5) feet on center. Do not drive posts through existing tree roots. Posts are six (6) feet in length with two (2) feet set into the ground and four (4) feet above ground. The fencing shall be attached to the post with a minimum of four (4) nylon locking ties evenly spaced at each post. Landscape protection fence be maintained throughout the duration of construction and must only be removed by direction of the Laboratory's Representative. Do not stake through roots.

G. Multiple trees may be enclosed by a single fence line, provided the fence is maintained at the drip line of all trees.

H. The Contractor must hand dig when in the drip line of protected trees.

I. Maintain a neat site appearance, including removal of trash and cutting of grass at protection fences, as directed by the Laboratory's Representative.

3.2 PRUNING & ROOT PRUNING

A. All pruning to be performed only by a Certified Arborist.

B. Coordinate site work schedule with Certified Arborist to ensure pruning meets project requirements.

C. Prune to meet current ANSI Standards, existing trees and shrubs to remain, as designated on plan.

D. Notify the Laboratory's Representative in writing of trees and shrubs not designated on plan which may require safety pruning. Receive Laboratory's Representative written direction prior to proceeding with work.

E. Prune trees and shrubs at time of year appropriate for species and variety, in timeframe not injurious to plant. Prune in accordance with standard horticultural practices to retain natural habit and shape of plant.
   1. Shearing of plants will not be accepted.
   2. Protect and preserve leader(s) promoting symmetrical growth on multiple leader plants.

F. Prune and trim dead wood, suckers, and injured twigs and branches.

G. Use only clean, sharp tools.

H. Make cuts flush and clean avoiding injury to branch bark ridge or branch collar leaving no stubs.

I. For cuts greater than 3/4 in. in diameter and bruises or scars on bark, trace injured cambium back to living tissue and remove. Smooth and shape wounds so as not to retain water.

J. Prune flowering trees only to remove dead or damaged branches. Do not remove leader.

3.3 REMOVAL

A. Tree removal in site landscape areas to remain must be performed by a certified arborist and landscape crew, trained and equipped to create minimal impact on landscape soil areas.

B. Remove tree root system to a depth of 10” below grade.

C. Chip all trimmings and dispose of removals in safe, legal manner, offsite as part of contract.

3.4 CLEAN UP

A. Upon completion of work, the Contractor is responsible for ensuring that all tree protection areas within the scope of work and adjacent areas that may have been impacted are clean and free of trash or debris.

B. Remove soil or similar material brought onto paved areas, keeping these areas clean.

C. Upon completion of planting, remove excess soil, stones, and debris and dispose of off-site in legal manner.

3.5 MAINTENANCE

A. Maintain protected trees and landscape areas through project substantial completion through provision and maintenance of protection devices as approved by Laboratory’s Representative.

B. Maintenance of protected plants during protection period includes watering, necessary cultivation, weeding, pruning, disease and insect pest control, protective spraying ensure normal, vigorous, and healthy growth.

3.6 ACCEPTANCE

A. Landscape Protection Acceptance: Upon substantial completion of the project, the Laboratory’s Representative will inspect protection for acceptance.
   1. Acceptance requires:
      a. Protected Trees flags to remain on trees, to be removed following acceptance.
      b. Plant material is inspected and healthy condition following Laboratory’s Representative inspection.
      c. Fences removed per direction of Laboratory’s Representative.
      d. Protected landscape areas are clean and returned to original appearance.
      e. Replanting related to tree replacements is complete and in accordance with contract.
      f. Landscape Protection Penalties are compensated to Laboratory.
      g. Items shall appear to be in general conformance with specifications and Landscape Protection Shop Drawing.

END OF SECTION

SECTION 31 20 00
EARTHWORK

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes: Earthwork required to complete the Project except as specified in related work.

B. Comply with the "Subsurface Exploration and Geotechnical Engineering Report for the Proposed Argonne National Laboratory (ANL) Advanced Protein Crystallization Facility (APCF), DuPage County, Illinois" dated May 18, 2011 as completed by AECOM.

1.02 RELATED DOCUMENTS

A. Section 31 23 33 Trenching and Backfilling .

B. Section 31 25 13 Erosion and Sedimentation Control.

C. Section 32 91 00 Soil Preparation, for mix, placement, and installation of engineered soils.

D. Geotechnical Report

1.03 SUBMITTALS

A. Samples
   1. Submit 10 lb samples of each material to be used. Identify source, type (use) of each material and gradation. Forward to Argonne National Laboratory's testing agency packed tightly in containers to prevent contamination. Submit copy of transmittal to Architect.

B. Submit directly to General Contractor invoices and delivery tickets indicating the amount and type of off-site materials delivered.

C. Submit "Settlement Monitoring Report" in accordance with Section 1.05.F.2. Submit "Stormwater Management Plan" in accordance with Section 3.02.B.

D. Product Data: For the following:
   1. Each type of plastic warning tape.
   2. Drainage fabric.
   3. Separation fabric.

E. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
   1. Classification according to ASTM D 2487 of each on-site or borrow soil material proposed for fill and backfill.
   2. Laboratory compaction curve according to ASTM D 698 for each on-site or borrow soil material proposed for fill and backfill.
   3. Laboratory compaction curve according to ASTM D 1557 for each on-site or borrow soil material proposed for fill and backfill.

F. LEED Submittals:

1. LEED Credit MR 4.1 and Credit MR 4.2: Submit product data for products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
   a. Include statement indicating costs for each product having recycled content.
2. LEED Credit MR 5.1 and Credit MR 5.2: Submit product data for products that have extracted, harvested, or recovered, as well as manufactured within 500 miles of the Project site.
   a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the Project site.

1.04 QUALITY ASSURANCE

A. Codes and Standards: Perform Work in compliance with applicable requirements of governing authorities having jurisdiction including the Department of Energy.

B. Soil Testing and Inspection Service:
1. Laboratory will engage a soil testing and inspection service, to include testing soil materials proposed for use in the Work and initial quality control testing during earthwork operations.
2. Furnish soil survey for satisfactory soil materials and samples of soil materials to the testing service.

1.05 PROJECT CONDITIONS

A. Site Information
1. Laboratory has had a subsurface investigation performed, the results of which are contained in a report. The report presents conclusions on the subsurface conditions based on their interpretation of the data obtained in the investigation.
2. The Contractor acknowledges that they have reviewed the subsurface investigation report and any addenda thereto.
3. It is recognized that a subsurface investigation may not disclose all conditions as they actually exist and other conditions may change, particularly groundwater conditions, between the time of a subsurface investigation and the time of earthwork operations.
4. The data on indicated subsurface conditions are not intended as representations or warranties of the continuity of such conditions. It is expressly understood that Laboratory and Architect will not be responsible for interpretations or conclusions drawn therefrom by the Contractor. The data are made available for the convenience of the Contractor.
5. Additional test borings and other exploratory operations may be made by the Contractor at no cost to Laboratory in full accordance with their requirements.

B. Traffic: Conduct operations to ensure minimum interference with roads, streets, walks, and other adjacent occupied or used facilities. Do not close or obstruct streets, walks or other occupied or used facilities without permission from authorities having jurisdiction.

C. Protection of Existing Improvements:

1. Provide barricades, coverings, or other types of protection necessary to prevent damage to existing improvements to remain in place.
2. Restore damaged improvements to their original condition, as acceptable to Laboratory and other parties or authorities having jurisdiction.

D. Existing Utilities:
1. Locate existing underground utilities in the areas of Work before starting earthwork operations. If utilities are to remain in place, provide adequate means of protection during earthwork operations to the satisfaction of the architect.
2. Contact Laboratory engineering staff to verify locations of existing underground utilities before starting evacuation.
3. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, consult the Architect immediately for directions as to procedure.
4. Cooperate with Laboratory and public and private utility companies in keeping their respective services and facilities in operation.
5. Demolish and completely remove from the site underground utilities indicated to be removed. Coordinate with Laboratories for shutoff of services if lines are active.

E. Use of Explosives: The use of explosives will not be permitted.

F. Protection:
1. Protect existing improvements on and off the site from damages caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
2. Settlement Monitoring: Readings: Contractor shall have the surveyor take readings of the work and adjacent property at the minimum number of points indicated below. Additional monitoring points may be established as the Contractor determines to be necessary. Provide a proposed written program for settlement monitoring prior to start of excavation or foundation work. Record readings weekly until the work is substantially complete.
   a. Street and Pedestrian Pavement on Grade: one hundred (100) feet on center along each vehicular and pedestrian roadway and walkway; vertical control.
   b. For all adjacent buildings, structures, curbs, walks, drives facing the Site: two (2) points for each location horizontal and vertical control.
   c. Reports: The Contractor shall submit a written report to the Laboratory's Representative and the Architect weekly.

PART 2 - PRODUCT

2.01 SOIL MATERIALS

A. General Fill: Provide soil materials conforming to ASTM D2487 soil groups GW, GR, GM, SW, SP or SM or a combination that are free of debris, waste, frozen materials, vegetable, organic , limestone, recycled concrete materials, recycled asphalt materials, and other deleterious matter and having maximum particle size of 2" in all dimensions.

B. Select Fill: Clean natural or crushed stone or gravel conforming to State of Illinois, Department of Transportation Gradation CA 6.

C. Recycled Fill: Crushed concrete conforming to State of Illinois, Department of Transportation Gradation CA 6.

D. Underbed Material: Naturally or artificially graded mixture of natural or crushed stone or gravel conforming to State of Illinois, Department of Transportation Specifications for Gradation CA 8, or CA 7.

E. Use Contractor supplied off-site material except that general fill may be from excavation if found acceptable by the Laboratory's testing service.

2.02 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, minimum 6 inches and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

B. Drainage Fabric, if required: Non-woven geotextile, specifically manufactured as a drainage geotextile; made from polyolefins, polyesters, or polyamides; and with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:

1. Grab Tensile Strength: 110 lbf (490 N); ASTM D 4632.
2. Tear Strength: 40 lbf (178 N); ASTM D 4533.
3. Puncture Resistance: 50 lbf (222 N); ASTM D 4833.
4. Water Flow Rate: 150 gpm per sq. ft. (100 L/s per sq. m); ASTM D 4491.
5. Apparent Opening Size: No. 50 (0.3 mm); ASTM D 4751.

C. Separation Fabric, if required: Woven geotextile, specifically manufactured for use as a separation geotextile; made from polyolefins, polyesters, or polyamides; and with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:

1. Grab Tensile Strength: 200 lbf (890 N); ASTM D 4632.
2. Tear Strength: 75 lbf (333 N); ASTM D 4533.
3. Puncture Resistance: 90 lbf (400 N); ASTM D 4833.
4. Water Flow Rate: 4 gpm per sq. ft. (2.7 L/s per sq. m); ASTM D 4491.
5. Apparent Opening Size: No. 30 (0.6 mm); ASTM D 4751.

PART 3 - EXECUTION

3.01 CLEARING

A. Removal of Improvements:

1. Remove improvements that interfere with construction.
2. Cap and remove or abandoned underground piping or conduit as indicated on the documents and as required by Laboratory.
3. Where uncharted or incorrectly charted below grade improvements are discovered, obtain approval of Architect before removal.

3.02 EXCAVATION

A. General:
1. Excavation consists of the removal and disposal of materials encountered when establishing the required grade elevations. Such excavation is unclassified regardless of the materials encountered and all materials are to be disposed of in accordance with local codes.
2. Unauthorized excavation consists of removal of materials beyond indicated or required elevations. Replace unauthorized excavation by backfilling and compacting as specified for select fill at no cost to Laboratory.
3. Excavation procedures shall be as recommended by Laboratory's testing agency.
4. Excavate under pavements as required to comply with cross sections, elevations and grades.
5. Excavate elsewhere as required to establish new finish grades, allowing not less than 4" for top soiling.
6. Provide over-excavation in areas denoted and to allow for placement of engineered soils (bioswale areas south of parking lots).

B. Dewatering:
1. Prior to commencing work, the Contractor shall provide a Stormwater Management Plan. This plan shall stipulate provisions for dewatering, pumping, collection, temporary storage, and discharge or disposal of storm water , perched water and other liquids, contaminated and/or uncontaminated, at the site so as to facilitate soil removal and minimize disposal costs for contaminated fluids.
2. Do not allow water to accumulate in excavations. Remove water from excavations to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to the stability of subgrades and foundations. Provide and maintain pumps, sumps, suction and discharge lines, and other dewatering system components necessary to convey the water away from the site.
3. Convey water removed from excavations and rainwater to collecting or run-off areas acceptable to authorities having jurisdiction. Do not use trench excavations for site utilities as temporary drainage ditches.
4. Comply with requirements of authorities having jurisdiction, including but not limited to, the IEPA and Department of Energy

C. Stability of Excavations:
1. Slope the side of excavations to comply with local codes, authorities having jurisdiction, and maintain same. Secure, shore, and brace where sloping is not possible either because of space restrictions or stability of material excavated.
2. Maintain sides and slopes of excavations in a safe condition until completion of backfilling.

D. Shoring and Bracing:

1. Provide shoring and bracing to comply with local codes, authorities having jurisdiction, the Department of Energy, and the latest Occupational Safety and Health Administration (OSHA) Requirements.
2. Provide materials for shoring and bracing, such as sheet piling, uprights, stringers and cross braces, in good serviceable conditions.
3. Maintain shoring and bracing in excavations regardless of the time period excavations will be open. Carry down shoring and bracing as the excavation progresses.

E. Material Storage: Stockpile excavated materials classified as satisfactory soil material in accordance with local codes until required for backfill or fill. Place, grade and shape stockpiles for proper drainage and to prevent production of dust and blowing of materials.

F. Excavation for Pavements: Cut the surface under pavements to comply with cross sections, elevations and grades.

G. Removal of Unsatisfactory Soil Materials:
1. Excavate unsatisfactory soil materials encountered that extend below the required elevations, to the additional depth established by the Laboratory's testing service and approved by Laboratory.
2. If excavated unsatisfactory materials are to be removed from the property, all such materials shall be disposed of in accordance with all local and federal codes. Provide additional environmental testing as required to classify unsatisfactory material that must be removed from the site.
3. Such additional excavation, provided it is not due to the fault or neglect of the Contractor, will be measured and paid for as a change in the Work if approved by Argonne National Laboratory.

H. Closing Abandoned Underground Utilities: Close open ends of abandoned underground utilities, which are to remain permanently, and with sufficiently strong closures to withstand pressures which may result after closing.

I. Cold Weather Protection: Protect excavation bottoms against freezing when the atmospheric temperature is less than 35 degrees F. Maintain excavation free of water, ice and snow.

3.03 PROOF ROLLING

A. Proof Roll entire area under building and pavements with a pneumatic roller or heavily loaded dump truck (minimum 25 tons).

B. Make at least two (2) passes (second at right angle to first) in the presence of a representative of Laboratory's testing service.

C. Excavate unsatisfactory soil materials encountered to the additional depth established by Laboratory's testing service and approved by National Laboratory.

D. Perform no further Work until slab subgrades are acceptable to the representative of the Laboratory's testing service.

3.04 COMPACTION

A. General: Control soil compaction during construction, providing the minimum percentage of density specified.

B. Percentage of Maximum Density Requirements: Provide not less than the following percentages of density of soil material compacted at ± 2% optimum moisture content, for the actual density of each layer of soil material-in-place:
   1. Compact top 12" of subgrade and each layer of backfill or fill material to 75% relative density for cohesionless soils (ASTM D 4253 & D 4254) and 95% maximum density for cohesive soil (ASTM D 1557).

C. Moisture Control:
   1. Where the subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to the surface of subgrade, or layer of soil material, to prevent free water appearing on the surface during or subsequent to compaction operations.
   2. Remove and replace, to scarify and air dry, soil material that is too wet to permit compaction to specified density.

3.05 BACKFILL AND FILL

A. Prior to Backfill Placement: Backfill excavations as promptly as the Work permits, but not until completion of the following:
   1. Review of construction below finish grade.
   2. Code required inspection, testing, approval, and recording locations of underground utilities.
   3. Removal of concrete formwork.
   4. Removal of shoring and bracing, and backfilling of voids with satisfactory materials. Cut off temporary sheet piling driven below bottom of structures and remove in manner to prevent settlement of the structure or utilities, or leave in place if required.
   5. Removal of trash and debris.
   6. Permanent or temporary horizontal bracing is in place on horizontally supported walls.

B. Ground Surface Preparation:
   1. Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to placement of fills. Plow, strip, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that fill material will bond with existing surface.
   2. When the existing ground surface has a density less than that specified under "Compaction" for the particular area classification, break up the ground surface, pulverize, bring moisture condition to the optimum moisture content, and compact to the required depth and percentage of maximum density.

C. Placement and Compaction:
   1. Place backfill and fill materials to required grades in layers not more than 8" in loose depth for materials compacted by heavy compaction equipment and not more

than 4" in loose depth for materials compacted by hand operated tampers. Before compaction, moisten or aerate each layer as necessary to provide the optimum moisture content of the soil material. Compact each layer to the required percentage of density.

2. Place backfill and fill materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.
3. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
4. Backfill and fill under pavements as required to comply with cross sections, elevations and grades shown.
   a. Use fill as specified in documents or select fill material, except below 3-foot, general fill may be used.
5. Backfill and fill elsewhere as required to comply with cross sections, elevations and grades shown.
   a. Use fill as specified in the documents or general fill, allowing not less than 4" for top soiling.

3.06 GRADING

A. General: Uniformly grade the area, including adjacent transition areas. Smooth finished surfaces within specified tolerances, compact with uniform levels or slopes between elevation points, or between such points and existing grades.

B. Grassed Areas: Finish areas to receive topsoil to within not more than 0.10' above or below the required subgrade elevations, compacted as specified, and free from irregular surface changes.

C. Walks: Shape the surface of areas under walks to line, grade and cross section, with the finish surface not more than 0.00' above or 0.10' below the required subgrade elevation, compacted as specified, and graded to prevent ponding of water after rains.

D. Pavements: Shape the surface of the areas under pavement to line, grade and cross section, with the finish surface not more than 1/4" above or below the required subgrade elevation, compacted as specified, and graded to prevent ponding of water after rains.

3.07 FIELD QUALITY CONTROL

A. Quality Control Testing During Construction:
   1. Laboratory's testing service must inspect and approve sub-grades and fill layers before further construction work is performed thereon.
   2. If, in the opinion of Laboratory’s testing service, based on reports of the testing service and inspection, the subgrade or fills which have been placed are below the specified density, additional compaction and testing will be required until satisfactory results are obtained at no additional cost to Laboratory. In such event, retesting will be paid by the Contractor.

B. Laboratory will engage a qualified independent testing and inspecting agency to sample materials, perform tests, and submit test reports during earthwork operations.

C. Contractor’s Responsibilities

1. Notify Agency sufficiently in advance of operations to allow for assignment of personnel and scheduling of tests.
2. Coordinate with Agencies' personnel; provide access to Work, to manufacturer's operations.
3. Provide preliminary representative samples of materials to be tested, in required quantities.
4. Furnish casual labor and facilities to provide access to Work to be tested to obtain and handle samples at the site to facilitate inspections and tests, and storage and curing of tests.
5. Arrange with laboratory, pay for, additional samples and tests required when initial tests indicate Work does not comply with Contract Documents.

D. Tests for Proposed Soil Materials:
1. Test soil materials proposed for use in the Work and promptly submit test result reports. Soil samples will be provided by Contractor.
2. Provide one optimum moisture-maximum density curve for each type of cohesive soil. Determine maximum densities in accordance with ASTM D 1557.
3. Determine the suitability of materials to be used as fill and backfill.
4. Perform a mechanical analysis (AASHO T88), plasticity index (AASHO T91), and frost susceptibility analysis.

E. Compaction Testing:
1. Inspect, test, and approve each lift of fill and backfill before next lift is placed. Test in accordance with ASTM D1556 or D2167 as appropriate.
2. Take a field density test for each 2,000 sq. ft. of backfill and fill under slabs and pavements.
3. Take a field density test at 100 foot intervals along the inside of continuous footings, but not less than one (1) test per 20 foot run.
4. Take a field density test for each four (4) isolated footings.
5. Take a field density test at 50 foot intervals along utility trench backfill under slabs and pavements.

F. Proofrolling Observation:
1. Provide continuous observation of proofrolling of entire building area. Four passes will be made.
2. Approve subgrade or make recommendations for removal.

G. Submittals: Submit copies of the following reports:
1. Report and certification of granular fill and drainage fill.
2. Test reports on fill and backfill material.
3. Verification of each footing subgrade.
4. Field density test reports.
5. One optimum moisture-maximum density curve for each type of soil encountered.
6. Report of actual unconfined compressive strength and/or results of plate bearing tests of each strata tested.
7. Other tests' and materials' certificates, as required.

3.08 MAINTENANCE AND RESTORATION

A. Protection of Graded Areas:

1. Protect newly graded areas from traffic and erosion, and keep free of trash and debris and growth of weeds.
2. Repair and reestablish grades in settled, eroded, and rutted areas to the specified tolerances.

B. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather scarifies the surface, reshape, and compact to the required density prior to further construction.

C. Restoration: Restore all areas affected by construction both on and off Laboratory's property to original condition.

3.09 DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Burning is not permitted on Laboratory's property.

B. Remove waste materials, excess excavated materials, excavated materials classified as unsatisfactory soil material from Laboratory property and legally dispose of all materials. All contaminated soils must be disposed of at a permitted landfill as special waste, certified non-special waste, or as directed.

END OF SECTION

SECTION 31 23 33
TRENCHING AND BACKFILLING

PART 1 - GENERAL

1.01 SUMMARY

A. Work Under this Sections Includes:

1. Excavation for trenches for water, sanitary sewer, and storm sewer lines to point of connection to existing infrastructure.
2. Compacted bed and compacted fill over utilities to subgrade elevations.

1.02 RELATED DOCUMENTS

A. 31 20 00 – Earthwork

B. 33 31 00 – Sewerage and Drainage

C. 33 11 00 – Water Service

D. Geotechnical Report

1.03 SUBMITTALS

A. Submit 10 lb samples of each material to be used. Identify source, type (use) of each material and gradation. Forward to Argonne National Laboratory's testing agency packed tightly in containers to prevent contamination. Submit copy of transmittal to Architect.

B. LEED Submittals:

1. LEED Credit MR 4.1 and Credit MR 4.2: Submit product data for products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
   a. Include statement indicating costs for each product having recycled content.
2. LEED Credit MR 5.1 and Credit MR 5.2: Submit product data for products that have extracted, harvested, or recovered, as well as manufactured within 500 miles of the Project site.
   a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the Project site.

C. Product Data: Warning Tape

1.04 TESTS

A. Tests and analysis of fill materials will be performed in accord with ASTM D1557.

1.05 REFERENCES

A. ASTM C136, - Sieve Analysis of Fine and Coarse Aggregates.

B. ASTM D1556, - Density of Soil in place by Sand-Cone Method.

C. ASTM D1557, - Tests for Moisture-Density Relationship of Soils and Soil-Aggregate Mixtures Using 10 lb. Rammer and 18 inch Drop.

D. Illinois Department of Transportation (IDOT):

1. IDOT 2012 Specifications for Road and Bridge Construction including all addenda.

1.06 PROTECTION

A. Protect excavations by shoring, bracing, sheet piling, underpinning or other methods or prevent cave-in or loose soil from falling into excavation.

B. Underpin adjacent structures which may be damaged by excavation work, including service utilities and pipe chases.

C. Notify Architect immediately of unexpected subsurface conditions. Confirm notification in writing. Discontinue work until Architect issues written notification to resume work.

D. Protect bottom of excavations and soil adjacent to and beneath foundations from frost.

E. Grade excavation tip perimeter to prevent surface water runoff into excavation.

PART 2 - PRODUCTS

2.01 SOIL MATERIALS

A. In accordance with the soil report, Laboratory's testing agency representative shall determine if newly imported material is suitable for trench backfill.

B. All bedding and backfill material shall be in accordance with ASTM D2321 and IEPA requirements.

C. Granular Fill for Bedding and Backfill of Sewer and Water Main: As indicated on the drawings and in accordance with IDOT 2012, Article 1003 and 1004. The material shall be graded from coarse to fine and shall conform to the following gradations as listed in IDOT 2012: FA-6, CA-6, CA-11, and CA-12.

D. Fill Material Type D: Fill material shall be cohesive soil obtained from on-site required excavations and approved by Laboratory’s testing agency representative as suitable backfill material in accordance with ASTM D 2487, Uniform Soils Classification System 1 and 703.5. It shall be used to backfill excavations where the excavated material is unsuitable for backfill.

E. Fill Material Type E: Fill under landscaped areas shall be free from alkali, salt shall not exceed Appendix B, Section 742, Table A, and shall be obtained from on-site required excavations when conforming to the specifications. This fill shall be approved by Laboratory testing agency representative as suitable material.

F. Fill Material Type X: Off-site borrow material shall comply with soil types GP, GW, SC and CL in accordance with ASTM D 2487. It shall be used where needed under structural slabs, roads, pavement and landscaped areas.

2.02 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, minimum 6 inches and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

PART 3 - EXECUTION

3.01 INSPECTION

A. Verify stockpiled fill to be reused as approved in writing by Architect.

B. Verify and confirm in writing that areas to be backfilled are free of debris, snow, ice or water, and surfaces are not frozen.

3.02 PREPARATION

A. Identify specified lines, levels, contours and data.

B. Compact subgrade surfaces to density specified for backfill materials.

3.03 EXCAVATION

A. Cut trenches wide enough to enable utility installation and allow inspection.

B. Hand trim excavation and leave free of loose matter. Hand trim for bell and spigot pipe joints.

C. Excavation shall not interfere with normal 45 degree bearing splay of foundations.

D. Sides, walls or faces of all trenches shall be sloped and maintained in a safe manner and in the required condition until completion of backfilling. Excavations shall be braced or sloped in compliance to the latest Occupational Safety and Health Administration (OSHA) requirements or as instructed by the testing agency on-site representative.

E. Locate and retain reusable excavated materials away from the edge of excavation.

3.04 BACKFILLING

A. Support pipes during placement and compaction of bedding fill.

B. Backfill trenches to contours and elevations shown. Backfill systematically, as early as possible to allow maximum time for natural settlement. Do not backfill over porous, wet or spongy subgrade surfaces.

C. Place compact fill materials in continuous layers as specified in Section 31 20 00.

D. Use a placement method that will not disturb or damage utilities in trenches, perimeter drainage.

E. Maintain optimum moisture content of backfill materials, determined by laboratory analysis, to obtain specified compaction density.

F. Remove surplus backfill materials and materials unsuitable for backfill from the site to state and local permitted/licensed facilities.

3.05 FILL TYPES AND COMPACTION

A. Compact all fill and backfill to specified values based on Modified Proctor Test in accordance with section 31 20 00.

3.06 COLD WEATHER PROTECTION

A. Quality Control Testing During Construction: An independent inspection and testing agency employed by Laboratory shall inspect and approve each subgrade and fill layer before further backfill and fill work is performed.

1. The inspection and testing agency shall perform field and laboratory density tests in accordance with either ASTM D 1556 (sand cone method) and ASTM D 1557 as applicable.
2. Field density tests may also be performed by the nuclear method in accordance with ASTM D 2922. The calibration curves shall be periodically checked and adjusted to correlate to tests performed using ASTM D 1556. In conjunction with each density calibration check, the calibration curves furnished with the moisture gauges shall be checked in accordance with ASTM D 3017.
3. If field tests are performed using nuclear methods, the inspection and testing agency shall make calibration checks on both density and moisture gauges at beginning of work, on each different type of material encountered, and at intervals as specified by the equipment manufacturer.
4. If, in the opinion of the Laboratory testing agency representative, based on the inspection and testing agency reports and inspections, subgrade or fills have been placed by specified density, the Contractor shall perform additional compaction and retesting until specified density contractor to pay for all retesting work.
5. The Contractor shall assist the inspection and testing agency by providing access to the excavation and fill areas, and by removing loose materials from compacted soil layers prior to testing.

3.07 STORAGE AND REMOVAL OF EXCAVATION MATERIALS

A. Remove surplus backfill materials and materials unsuitable for backfill from the site as required by Laboratory.

B. Locate and retain reusable excavated materials away from the edge of excavation.

C. Remove excess and deleterious materials. The hauling of materials to designated areas shall be at the Contractor's expense and shall be conducted per all regulatory codes.

END OF SECTION

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SECTION 31 25 13
EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.01 SUMMARY

A. Scope: Furnish all materials, labor, equipment and services necessary for and reasonably incidental to the proper execution of the project as shown on drawings and/or specified and/or directed.

B. Description: Erosion control for this work includes, but is not limited to earthwork and grading operations.

1.02 RELATED DOCUMENTS

A. 02 41 00 – Demolition and Removal

B. 31 20 20 – Earthwork

1.03 SUBMITTALS

A. Submit sediment and erosion plan and Stormwater Management Plan, specific to the site that complies with project documents and the Stormwater Pollution Prevention Plan (SWPPP).

B. Product Data:

1. Silt Fence Geotextile Fabric
2. Filter Basket
3. Flared end section sediment barrier.

C. LEED Submittals:

1. LEED Credit MR 4.1 and Credit MR 4.2: Submit product data for products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
   a. Include statement indicating costs for each product having recycled content.
2. LEED Credit MR 5.1 and Credit MR 5.2: Submit product data for products that have extracted, harvested, or recovered, as well as manufactured within 500 miles of the Project site.
   a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the Project site.

1.04 QUALITY ASSURANCE

A. Qualifications of Workers: At least one person who is thoroughly familiar with the types of materials and equipment being utilized shall be present at all times during the operations to direct the work where required.

B. Codes and Standards: In addition to complying with all pertinent local codes and regulations, all work shall be in accordance with the State of Illinois, “Standard Specifications for Road and Bridge Construction”, latest edition.

1.05 JOB CONDITIONS

A. Protection: Use all means necessary to protect existing objects designated to remain and, in the event damage, immediately make all repairs and replacements necessary to the approval of the Architect at no additional cost to Laboratory.

1.06 CONTROL REQUIREMENTS

A. All earth changes shall be made in such a manner as to minimize:

1. The area disturbed land exposed and unprotected against the erosive action of wind, ice, precipitation, and the flow of water; and
2. The duration of such exposure.

B. Sediment caused by accelerated soil erosion shall be restricted to a non-polluting minimum, before it leaves the site of the earth-change.

C. Sediment caused by accelerated soil erosion shall not be permitted to enter the storm water structures of wetland located on or near the site. Temporary control measures shall be created and maintained until the completion of the project.

PART 2 - PRODUCTS

2.01 SILT FENCE

A. Geotextile Filter Fabric: A nonwoven fabric consisting of previous sheets of propylene, nylon, polyester, or ethylene yarn. Certify material by manufacturer to meet the following requirements. Pre-assembled silt fencing may be substituted if it meets the below requirements.

1.	Property	Test Method	Requirements
2.	Minimum Tensile Strength	ASTM D4632	90 lb
3.	Maximum Elongation at 45 lb	ASTM D4632	50% Max
4.	Apparent Opening Size	ASTM D4751	AOS<0.60 mm
5.	Minimum Permittivity	ASTM D4491	1x10-2 SEC -1
6.	Ultraviolet Exposure Strength Retention	ASTM D4355	70% @ 500h

B. Posts: Wood or steel and a minimum 5 ft long. Wood posts shall be at least 4 in. dia. Or nominal 2 x 2 in. Steel posts shall be round or “U”, “T”, or “C” shaped with a minimum weight of 1.33 lb/ft and projections for fastening wire to fence.

C. Wire Staples: 9 gage and minimum 1 in. long.

2.02 FILTER BASKET

A. Shall be installed at all open-grate drainage structures defined in the project drawings.

B. Manufacturers:

1. Catch - All
   a. Price and Company, Inc.
   b. 29165 Wall Street
   c. Wixom, MI 48393-3525
   d. T: 866.960.4300
   e. F: 248.596.4301
2. Flexstorm

a. Inlet and Pipe Protection, Inc
b. 24137 W. 111th Street Unit A
c. Naperville, IL 60564
d. T: 866.287.8655
e. F: 630.355.3477

2.03 SEDIMENT BARRIER

A. As shown on drawings.

2.04 CONSTRUCTION ENTRANCE

A. Aggregate size: CA-1 or CA-4.

B. Geotextile fabric: Shall meet the requirements specifications 592 Geotextile table 1 or 2, class I, II, or IV of the Illinois Urban Manual.

PART 3 - EXECUTION

3.01 GENERAL

A. Do not start operations until the erosion and sediment control plan has been submitted and features are in place.

B. Comply with "Quality Assurance" provisions of these specifications, the erosion and sediment control plan, and as follows to ensure the LEED credit SSPI is achieved.

C. Schedule the Work in start to finish phases to minimize exposing the site to erosion.

D. Install erosion and sediment control features before site disturbance begins and immediately after new inlets are installed.

E. Do not allow storm water to flow into excavations and disturbed areas.

F. Do not discharge water into sanitary sewers, watercourses or offsite.

G. Do not discharge water-containing sediment in accordance with "Quality Assurance" requirements and as presented in the erosion and sediment control plan submittal or a maximum retained as 30 milligrams of sediment per liter of water. Conduct continuous monitoring of sediment.

H. Maintain sediment control features. Inspect weekly and after every rain. Repair damaged bales, end runs and undercutting beneath bales. Repair breaks in diversion dams and damage down streams of the break. Replace damaged and deteriorated filter fabric and fences. Remove sediment which deposits fill 1/3 of the fabric surface area.

I. Do not allow sediment to flow into vegetated areas.

J. Retain all sediment on the site. Provide temporary stone roadways at exits from the site to ensure mud run-off of tires before exiting.

K. Utilize the sizes of equipment appropriate to the task to minimize exhaust, noise and vibration.

L. Mist or provide other means to keep dust from being scattered to the air.

3.02 INSTALLATION/APPLICATION/ERECTION

A. General: Control surface water runoff on-site and provide temporary soil stabilization measures as required to prevent erosion of soil by action of water. Protect storm sewers adjacent to work site from sedimentation by installation of erosion and sediment control measures. Provide, as a first step in construction operations, barriers, and other measures intended to deter erosion and transport of sediment associated with construction activities before construction starts or as it progresses.

3.03 TEMPORARY STOCKPILES

A. Steps shall be taken to minimize erosive loss from stored piles of excavated spoils, topsoil, etc. Control methods used may include covering, temporary stabilization, compacting, diversion ditches, silt fence, straw bales, etc. separately or in combination, as may be dictated by the size, type, location, season, and anticipated duration of storage.

B. Stockpiles shall not be placed in flood prone areas or stormwater storage areas.

END OF SECTION

SECTION 32 12 16
HOT MIX ASPHALT PAVING

PART 1 - GENERAL

1.01 SUMMARY

A. Work under this section includes:
   1. Cold milling of existing hot-mix asphalt pavement, hot-mix asphalt paving, patching, and paving overlay.

1.02 RELATED DOCUMENTS

A. 31 20 00 – Earthwork for aggregate base and subbase courses and for aggregate pavement shoulders.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
   1. Job-Mix Designs from manufacturer. Indicate location for intended use.
   2. Illinois Department of Transportation Certification [IDOT] of approval for each job mix design proposed for the Work.

B. Material Certificates: For each paving material, from manufacturer.

C. LEED Submittals:
   1. LEED Credit MR 4.1 and Credit MR 4.2: Submit product data for products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. LEED Credit MR 5.1 and Credit MR 5.2: Submit product data for products that have extracted, harvested, or recovered, as well as manufactured within 500 miles of the Project site.
      a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the Project site.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by IDOT.

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the Illinois Department of Transportation—refer to IDOT Standard Specification for Road and Bridge Construction 2012 [SSRBC] for asphalt paving work.

C. Conduct pavement construction operations in accordance with the IDOT Specifications.

D. Preinstallation Conference: Conduct conference at Project site.

1.05 PROJECT CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
   1. Tack Coat: Minimum surface temperature of 60 deg F or as approved by manufacturer.
   2. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
   3. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

PART 2 - PRODUCTS

2.01 PAVING MATERIALS

A. Granular Base Course: Complying with requirements of IDOT Standard Specifications, Section 311, for type B base course with gradation CA-6 crushed stone.

B. Hot Mix Asphalt Binders, Surface Courses and Materials: Complying with IDOT Standard Specifications, Section 1030, Class I.
   1. Hot-mix Asphalt Surface Course: Complying with IL-9.5L, N 30 of the IDOT Standard Specifications, unless indicated otherwise on plans.
   2. Hot-Mix Asphalt Binder Course: Complying with IL-19L, N50 of the IDOT Standard Specifications, unless indicated otherwise on plans.
   3. Reclaimed Asphalt Pavement (RAP): RAP, complying with IDOT Standard Specifications shall be used in the HMA mix design and must comply with the following:
      a. No more than 25% of the proposed asphalt mix is allowed to be RAP material.
      b. RAP material shall be free of contamination, including, but not limited to, dirt, sand, brick, debris, concrete, sheet asphalt, sealant materials, and clean stone.

2.02 AUXILIARY MATERIALS

A. Sand: ASTM D 1073, Grade Nos. 2 or 3

B. Paving Geotextile: AASHTO M 288, nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications.

C. Joint Sealant: ASTM D 6690, Type II or III, hot-applied, single-component, polymer-modified bituminous sealant.

D. Pavement-Marking: Thermoplastic pavement marking per IDOT SSRBC 2012 section 1095.01.

1. Colors: provide color(s) as indicated on the Drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proceed with paving only after unsatisfactory conditions have been corrected.

C. Commencement of asphalt paving work will be an indication of the acceptance of sub-grade and the Contractor will be held responsible for the satisfactory execution and results of the finished work.

3.02 MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before milling operations. Remove existing asphalt pavement by milling in accordance with SSRBC Section 406.
   1. Grinding and milling operations shall comply with all local and federal regulations.

3.03 PATCHING

A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Pavement base: Prepare, construct, and/or reconstruct pavement base in accordance with the IDOT-SSRBC and all local and federal regulations.

C. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.05 to 0.15 gal./sq. yd.
   1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
   2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Patching: Fill excavated pavements with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

3.04 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Verify that prepared subgrade is ready to receive paving.

B. Subgrade: Shall have a minimum Illinois Bearing Ratio (IBR) of 2.0 and comply with requirements of IDOT Standard Specifications, Section 301. Subgrade shall be proof-rolled in accordance with Division 31 Section, "Earthwork."

C. Herbicide Treatment: Where required or as directed by Project Engineer or Architect, apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted aggregate base before applying paving materials. Mix herbicide with prime coat if formulated by manufacturer for that purpose.

D. Tack Coat: Apply uniformly to existing pavement surfaces at a rate of 0.05 - 0.10 gal./sq. yd.
   1. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
   2. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
   3. Prohibit traffic across tack coat for period not less than that required by manufacturer.

E. Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.25 - 0.50 gal. / sq. yd. Apply enough material to penetrate and seal but not flood surface. Allow prime coat to cure fully. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated. Protect primed substrate from damage until ready to receive paving.

F. Apply surfaces of manholes and catch basins that are to remain free of asphalt with oil to prevent asphalt adhesion.

3.05 HOT-MIX ASPHALT PLACING

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
   1. Spread mix at minimum temperature of 250 deg F or as directed by manufacturer.
   2. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

D. Installation of hot mix asphalt shall be in accordance with IDOT-SSRBC.

3.06 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
3. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
5. Construct Joints in accordance with IDOT specifications.

3.07 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.
   1. Complete compaction before mix temperature cools to 185°F or as recommended by manufacturer.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
   1. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent nor greater than 96 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

G. Erect barricades and traffic/pedestrian control devices to protect paving from traffic until mixture has cooled enough not to become marked.

3.08 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
   1. Base Course: Plus or minus 1/4 inch.
   2. Surface Course: Plus 1/4 inch, no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:

1. Base Course: 1/4 inch.
2. Surface Course: 1/8 inch.
3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

3.09 PAVEMENT MARKING

A. Do not apply thermoplastic pavement-marking until layout, colors, and placement have been verified with Architect.

B. Allow pavement to cure in the allotted time prior to applying pavement markings, follow manufacturer’s recommendation.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply thermoplastic pavement markings with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Laboratory will engage a qualified testing agency to perform tests and inspections.

B. Replace and compact hot-mix asphalt where core tests were taken.

C. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.11 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.

END OF SECTION

SECTION 32 13 13
PORTLAND CEMENT CONCRETE PAVING

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes Portland cement concrete paving required to complete the project.

1.02 RELATED DOCUMENTS

A. 31 20 00 – Earthwork

B. 32 13 16 – Specialty Concrete

C. 32 13 73 - Site Joint Sealants

D. Geotechnical Report

1.03 SUBMITTALS

A. Laboratory Test Reports: Submit 2 copies of laboratory test reports of concrete materials and mix design tests.

B. Delivery Tickets: Submit copies of delivery tickets for each load of concrete delivered to the site to the General Contractor.

C. Product Data: Submit copies of manufacturer's specifications with application and installation instructions for proprietary materials and items upon request.

D. Mock Ups: Color samples for selection of integral color admixture tint.

E. LEED Submittals:

1. LEED Credit SS7.1: Submit product data indicating the Solar Reflective Index (SRI) is 29 or greater.
2. LEED Credit MR 4.1 and Credit MR 4.2: Submit product data for products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
   a. Include statement indicating costs for each product having recycled content.
3. LEED Credit MR 5.1 and Credit MR 5.2: Submit product data for products that have extracted, harvested, or recovered, as well as manufactured within 500 miles of the Project site.
   a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the Project site.

1.04 QUALITY ASSURANCE

A. Perform work in accordance with reference IDOT Standard Specifications for Road and Bridge Construction 2012 Specifications and Department of Energy requirements.

B. Obtain materials from same source throughout.

C. Regulatory Requirements:
1. Illinois Steel Products Procurement Act as amended (Illinois Revised Statues, Ch. 48, par. 1901 et. seq.).
2. Department of Energy
3. Laboratory.

D. Concrete Testing Service:
1. Laboratory will employ a separate testing laboratory to perform initial field quality control testing.
2. Materials and installed Work may require testing and retesting at any time during the progress of the Work. Allow free access to material stockpiles and facilities at all times. Retesting of rejected materials and installed Work shall be done at the Contractor's expense.
3. Three concrete test cylinders shall be taken for every 75 or less cu. yds. of each class of concrete placed each day.
4. One additional test cylinder shall be taken during cold weather and be cured on site under same conditions as concrete it represents.
5. One slump test shall be taken for each set of test cylinders taken.

PART 2 - PRODUCTS

2.01 FORM MATERIALS

A. Comply with IDOT Specification, section 420.

2.02 REINFORCEMENT

A. Reinforcing steel: ASTM A615: Grade 60, epoxy coated finish.

B. Welded steel wire fabric: Plain type, ASTM A185; rolls; epoxy coated finish.

C. Tie wire: Annealed steel, minimum 16 gauge size.

D. Dowels: ASTM A615; Grade 40, plain steel, epoxy coated finish.

2.03 ACCESSORIES

A. Curing compound: Comply with IDOT Specification, Article 1020.13.

B. Liquid surface sealer. ASTM D-3405.

C. Preformed joint filler: ASTM D1751.

2.04 AUXILLARY MATERIALS

A. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than 45 minutes.

1. Colors: As indicated as indicated on the drawings.

2.05 EMBEDMENTS

A. Wet set truncated dome detectable warning tiles as indicated in the Drawings.

2.06 ADMIXTURES

A. Air entrainment admixture: Comply with ASTM C 260.

B. Chemical admixture: Comply with ASTM C94.

2.07 ADMIXTURE TINTS

A. Integral color for use in contrasting flush curb at building entry.

B. Final color selection by Architect of dry mix colors as supplied by following manufacturers:
   1. SGS Integral Colors by Solomon Colors, color #920 'Slate' or selection, www.solomoncolors.com.
   2. Uni-Mix by Butterfield Color, www.butterfieldcolor.com, color 'Gull gray' or selection.
   3. Chromix or Chromix P Admixture by Scofield System, www.scofield.com, color #3987 'Porcelain Gray' or #1266 'Cool Gray'.

2.08 CONCRETE MIX

A. Mix concrete in accordance with IDOT 2012, Section 1020, for Class PV Concrete. Also mix in accordance with Section 1020.11.

B. Provide concrete for paving of the following characteristics:
   1. Compressive strength at:
      a. 14 days: (3500) psi.

C. Use accelerating admixtures in cold weather only with Architect prior written approval. Use of admixtures will not relax cold weather placement requirements.

D. Add air entraining agent to concrete mix for concrete work subject to freeze/thaw cycling and exposed to exterior.

E. Mix and utilize admixture tints per manufacturer's recommendations. No plasticizers will be allowed.

PART 3 - EXECUTION

3.01 SUBGRADE PREPARATION

A. Prepare in accordance with IDOT 2012, Section 301.

B. Proof roll areas under drives and parking areas in accordance with Geotechnical Report.

C. Provide additional fill for soft spots and hollows.

D. Level and Compact subgrade, to receive granular base for concrete work, to 95% Modified Proctor Density.

3.02 CONCRETE PLACING

A. Place all paving, concrete base slab, and pad concrete in accordance with IDOT 2012, Section 420.

B. Place concrete for sidewalks in accordance with IDOT 2012, Section 424.

C. Cure concrete in accordance with IDOT 2012, Section 1020.13.

3.03 INSPECTION

A. The Testing Laboratory shall verify that the compacted base is ready to support paving and imposed loads.

B. Verify gradients and elevations of base are correct.

C. Start of installation constitutes acceptance of existing conditions.

3.04 PREPARATION

A. Moisten base to minimize absorption of water from fresh concrete.

B. Notify Architect minimum 48 hours before start of concreting operations.

3.05 FORMING

A. Place and secure forms to correct location, dimensions and profile.

B. Assemble formwork to permit easy stripping and dismantling without damaging concrete.

C. Place joint fillers vertical in position, in straight lines. Secure to formwork during concrete placement.

3.06 REINFORCEMENT

A. See drawings for reinforcement locations, dimensions, and placement within slab.

B. Interrupt reinforcement at contraction and expansion joints per project documents.

C. Place reinforcement to achieve slab and curb alignment as detailed.

D. Provide dowelled joints at interruptions of concrete with one end of dowel set in capped sleeve (slip dowel) to allow longitudinal movement.

E. All reinforcement to be epoxy coated.

3.07 FORMED JOINTS

A. Place expansion, control and contraction joints as shown on the drawings. Align curb, gutter and sidewalk joints.

B. Place joint filler between paving components and building (s) or other appurtenances. Recess top of filler 1/2 inch for sealer placement in accordance with documents.

C. Provide scored, joints at 5 feet intervals of sidewalk except where otherwise shown.

3.08 CURING

A. Curing and protection shall be as outlined in IDOT Sections 1020. White pigmented curing compound as outlined in IDOT Section 1022 is the preferred curing method. White-opaque polyethylene film shall not be accepted as a curing method.

3.09 FINISHING

A. Area paving: Light broom.

B. Sidewalk paving: Light broom, perpendicular to direction of travel, radiuses and trowel joints edges, wood float. Provide sawcut joints where noted in drawings and as per detail in drawings.

C. Curbs, flush curbs, and gutters: Light broom.

D. Place curing compound on exposed concrete surfaces immediately after finishing. Apply in accordance with manufacturer's current printed instructions.

3.10 FIELD QUALITY CONTROL

A. Maintain record of placed concrete items. Record date, location of pour, quantity, air temperature and test samples taken.

3.11 PROTECTION

A. Immediately after placement, protect concrete from premature drying, excessive hot or cold temperatures and mechanical injury. Maintain protection until accepted.

3.12 FIELD QUALITY CONTROL

A. Initial Testing: Laboratory will employ a separate testing laboratory to perform field quality control testing.

B. Additional Tests: The testing service will make additional tests of in-place concrete when test results indicate the specified concrete strengths and other characteristics have not been attained in the structure, as directed by the Architect. The Contractor shall pay for such tests conducted, and any other additional testing as may be required, when unacceptable concrete is verified.

C. Formed Concrete Dimensional Tolerances:

1. Formed concrete having any dimension smaller or greater than required, and outside the specified tolerance limits, will be considered deficient in strength and subject to additional testing as herein specified.
2. Formed concrete having any dimension greater than required will be rejected if the appearance or function of the structure is adversely affected, or if the larger dimensions interfere with other construction. Repair, or remove and replace rejected concrete as required to meet the construction conditions. When permitted, accomplish the removal of excessive material in a manner to maintain the strength of the section without affecting function and appearance.

D. Defective Work: Concrete work which does not conform to the specified requirements, including strength, tolerances, and finishes, shall be corrected at the Contractor's expense, without extension of time therefore. The Contractor shall also be responsible for the cost of corrections to any other work affected by or resulting from corrections to the concrete work.

END OF SECTION

SECTION 32 13 73
SITE JOINT SEALANTS

PART 1 - GENERAL

1.01 SUMMARY

A. Site joint sealants as indicated on the drawings and specified herein, including the following:
   1. Required applications of sealants include the following general locations: Curb, exterior slab, and sidewalk joints.

1.02 RELATED DOCUMENTS

A. 32 12 16 – Hotmix Asphalt Paving

B. 32 13 13 – Concrete Paving

C. 03 40 00 – Site Precast Concrete

1.03 QUALITY ASSURANCE

A. Perform work in accordance with IDOT Standard Specifications for Road and Bridge Construction 2012 Specifications.

B. Manufacturers: Firms with not less than five years of successful experience in production of types of sealants required for this project.
   1. Obtain elastomeric sealants from a manufacturer which will, upon request, send a qualified technical representative to the project site for purpose of advising General Contractor on proper procedures for use of products.

C. General Contractor: A firm with a minimum of five years of successful experience in application of type of materials required.

1.04 SUBMITTALS

A. Product Data: Submit manufacturer's specification, recommendations and installation and instructions for each type of sealant and associated miscellaneous material required.

B. Samples: Submit three 12-inch long samples of each color required (except black) for each type of sealant exposed to view. Install sample between two strips of material similar to or representative of typical surfaces where compound will be used, held apart to represent typical joint widths and shape.

C. LEED Submittals:
   1. LEED Credit MR 4.1 and Credit MR 4.2: Submit product data for products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.

2. LEED Credit MR 5.1 and Credit MR 5.2: Submit product data for products that have extracted, harvested, or recovered, as well as manufactured within 500 miles of the Project site.
   a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the Project site.

1.05 JOB CONDITIONS

A. Weather Conditions: Do not proceed with installation of sealants under adverse weather conditions, or when temperatures are below or above manufacturer's recommended temperature range for installation. Proceed with the work only when the weather conditions are favorable for proper cure and development of high early bond strength. Where joint width is affected by ambient temperature variations, install elastomeric sealants only when temperatures are in lower third of the manufacturer's recommended installation temperature range so that sealant will not be subject to excessive elongations and bond stress at subsequent low temperatures.

1.06 SPECIAL PROJECT WARRANTY

A. Sealant Warranty: Provide written warranty, signed by manufacturer and General Contractor agreeing to, within warranty period of six years after date of substantial completion replace/repair defective materials and workmanship defined to include: instances of leakage or water or air; failures in joint adhesion, material cohesion, abrasion resistance, strain resistance, or general durability; failure to perform as required and the general appearance of deterioration in any other manner not clearly specified in manufacturer's published project literature as an inherent characteristic of the sealant material.

PART 2 - PRODUCTS

2.01 MATERIAL

A. Provide manufacturer's standard, non-modified two or more part, polyurethane-based elastomeric sealant; comply with either ASTM C920 Type M Class 25, FS TT-S 00227E Class A; self-leveling grade/type. Submit color samples to match adjacent surface color for approval by Architect/Engineer.

B. Provide product of one of the following manufacturers:
   1. Contech/Sonneborn
   2. Mameco International
   3. W. R. Meadows, Incorporated
   4. Pecora Corporation
   5. Products Research and Chemical Corporation
   6. Sika Chemical Corporation
   7. Toch/Carboline
   8. Tremco, Incorporated
   9. Dow

2.02 MISCELLANEOUS MATERIALS

A. Joint Cleaner: Provide type of joint cleaning compound recommended by sealant manufacturer for joint surfaces to be cleaned.

B. Joint Primer/Sealer: Provide type of joint primer/sealer recommended by sealant manufacturer for joint surfaces to be primed or sealed.

C. Bond Breaker Tape: Polyethylene tape or other plastic tape as recommended by sealant manufacturer to be applied to sealant-contact surfaces where bond to substrate or joint filler must be avoided for proper performance of sealant. Provide self-adhesive tape where applicable.

D. Sealant Backer Road: Compressible rod stock polyethylene foam, polyethylene jacketed polyurethane foam, butyl rubber foam, neoprene foam, or other flexible, permanent, durable non-absorptive material as recommended for compatibility with sealant by the sealant manufacturer. Provide size and shape or rod which will control joint depth for sealant placement, break bond of sealant at bottom of joint depth for sealant placement, break bond of sealant at bottom of joint, form optimum shape of sealant bead on back side, and provide a highly compressible backer to minimize possibility of sealant extrusion when joint is compressed.

PART 3 - EXECUTION

3.01 EXAMINATION

A. The General Contractor must examine joint surfaces, backing, and anchorage of units forming sealant rabbet, and conditions under which sealant work is to be performed, and notify Architect/Engineer in writing of conditions detrimental to proper completion of the work and performance by sealants. Do not proceed with sealant work until unsatisfactory conditions have been corrected in a manner acceptable to General Contractor.

3.02 JOINT SURFACE PREPARATION

A. Clean joint surfaces immediately before installation of sealant. Remove dirt, insecure coatings, moisture, and other substances which would interfere with bond of sealant.

B. Etch concrete and masonry joint surfaces to remove excess alkalinity, unless sealant manufacturer’s printed instructions indicated that alkalinity does not interfere with sealant bond and performance.

C. Etch with 5 percent solution of muriatic acid; neutralize with dilute ammonia solution; rinse thoroughly with water and allow to dry before sealant installation.

D. Roughen joint surfaces in vitreous-coated and similar non-porous materials, where sealant manufacturer’s data indicate lower bond strength than for porous surfaces. Rub with fine abrasive to produce a dull sheen.

3.03 INSTALLATION

A. Comply with sealant manufacturer's printed instructions except where more stringent requirements are shown on specified and except where manufacturer's technical representative directs otherwise.

B. Prime or seal joint surfaces where shown or recommended by sealant manufacturer. Do not allow primer/sealer to spill or migrate onto adjoining surfaces.

C. Install sealant backer rod for liquid sealants, except where shown to be omitted or recommended to be omitted by sealant manufacturer for the application shown.

D. Install bond breaker tape where shown and where required by manufacturer's recommendations to ensure that elastomeric sealants will perform properly.

E. Employ only proven installation techniques, which will ensure that sealants will be deposited in uniform, continuous ribbons without gaps or air pockets, with complete "wetting" of joint bond surface equally on opposite sides. Except as otherwise indicated, fill sealant rabbet to a slightly concave surface, slightly below adjoining surfaces. Where horizontal joints are between a horizontal surface and a vertical surface, fill joint to form a slight cove so that joint will not trap moisture and dirt.

F. Install sealants to depths as shown or, if not shown, as recommended by sealant manufacturer but within the following general limitations, measured at center (thin) section or bead:
   1. For sidewalks, pavements, and similar joints sealed with elastomeric sealant and subject to traffic and other abrasion and indentation exposures, fill joints to a depth equal to 75 percent of joint width, and neither more than 5/8 inch deep nor less than 3/8 inch deep.
   2. For normal moving joints sealed with elastomeric sealants, but not subject to traffic, fill joints to a depth equal to 50 percent of joint width, but neither more than ½ inch deep, nor less than ¼ inch deep.

G. Spillage: Do not allow sealants to overflow or spill onto adjoining surfaces, or to migrate into voids of adjoining surfaces. Use masking tape or other precautionary devices to prevent staining of adjoining surfaces by primer/sealer.

H. Remove excess and spillage of sealants promptly as the work progresses. Clean adjoining surfaces by whatever means may be necessary to eliminate evidence of spillage, without damage to adjoining surfaces or finishes.

3.04 CURE AND PROTECTION

A. Cure sealants in compliance with manufacturer's instructions and recommendations to obtain high early bond strength, internal cohesive strength, and surface durability. Do not cure in a manner which would significantly alter materials modules of elasticity of other characteristics.

B. General Contractor shall advise Architect/Engineer of procedures required for curing and protection of sealants during construction period so that they will be without deterioration or damage (other than normal wear and weathering) at time of A/E acceptance.

END OF SECTION

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SECTION 32 14 13

CONCRETE UNIT PAVING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Custom Concrete Pavers:
   1. Setting: Bituminous on rigid base.

1.2 RELATED SECTIONS

A. Section 03 30 00 - Cast-In-Place Concrete.

B. Section 03 40 00 – Site Precast Concrete.

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):
   1. C33 - Specification for Concrete Aggregates.
   2. C67 - Method of Sampling and Testing Brick and Structural Clay Tile.
   3. C140 - Methods of Sampling and Testing Concrete Masonry Units.
   4. C144 - Specification for Aggregate for Masonry Mortar.
   5. C150 - Specification for Portland Cement.
   6. C207 -Specification for Hydrated Lime for Masonry Purposes.
   7. C595 - Specification for Blended Hydraulic Cements.
   8. C618 - Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
   9. C936 - Specification for Solid Concrete Interlocking Paving Units.
   10. D422 - Test Method for Particle-Size Analysis of Soils.
   11. D1557 - Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).
   12. D2167 - Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
   13. D3776 - Test Methods for Mass Per Unit Area (Weight) of Woven Fabric.
   14. ASTM C 33 - Specification for Concrete Aggregates.
   15. ASTM C 150 - Specification for Portland Cement.
   16. ASTM C 67 - Method of Sampling and Testing Brick and Structural Clay Tile.
   17. ASTM C 140 - Specification for Concrete.
   18. D3786 - Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics - Diaphragm Bursting Strength Tester Method.
   19. D4491- Test Methods for Water Permeability of Geotextiles by Permittivity.
   20. D4533 - Test Method for Trapezoid Tearing Strength of Geotextiles.
   21. D4632 - Test Method for Grab Breaking Load and Elongation of Geotextiles.
   22. D4833 - Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

B. IDOT Standard Specifications for Bridge and Roadway Construction, 2012 edition.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 33 00 “Submittal Procedures”.

B. Product Data: Manufacturer's data sheets on each product to be used, including:
1. Test Reports: Three copies, showing compliance with specified ASTM requirements.
2. Preparation instructions and recommendations.
3. Storage and handling requirements and recommendations.
4. Installation methods.
5. Submit copy of Quality Assurance and Procedure program.

C. LEED Submittals
1. Product Data for Credit MR 4.1 and MR 4.2: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.
   a) Include statement indicating cost for each product having recycled content.
2. Product Certificates for Credit MR 5.1 and MR 5.2: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.

D. Shop Drawings:
1. Layout drawings of each paved area showing the pattern of custom pavers, indicate pavers requiring cutting, indicate setting bed methods in each area, drainage patterns and drains. Include details of setting beds, noting all materials and their thickness, show details at walks and vertical bench surfaces.
2. Unit paving: Include full layout for patio, including typical and custom piece sizes, dimensions, sections, reinforcement and finishes. Verify all measurements in field prior to preparation of Shop Drawings.

E. Selection Samples: Two complete sets of color chips representing fabricator's full range of available colors and textures.

F. Verification Samples: For each finish product selected, three 6” x 6” sample pavers of manufactured color and texture selected. Include in each set of samples the full range of exposed color and texture to be expected in the completed Work.

1. Color to be a custom mix design to include 15%-20% Black Beauty Aggregate.

G. Warranty
1. Submit testing certification showing capability of pavers proposed to comply with the specified strength requirement.
2. During construction, submit field test reports in accordance with the testing schedule.

1.5 PERFORMANCE REQUIREMENTS

A. Compressive Strength: 5000 psi.

B. Air Content 6-8%

C. Water-Cement Ratio: 45:1

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications:
1. Products shall be produced by a single manufacturer unless otherwise specified.
2. Manufacturer shall submit evidence of having not less than fifteen years successful production of this product.
3. The paver manufacturer shall demonstrate, either by proven field performance or a laboratory freeze-thaw test, that the paving units have adequate durability if they are to be subjected to a freeze-thaw environment.
a. Satisfactory field performance is indicated when units similar in composition and made with the same manufacturing process as those to be supplied to the purchaser, do not exhibit objectionable deterioration after at least 3 years.
b. The units used as the basis for proven field performance shall have been exposed to the same general type of environment, temperature range and traffic volume as is contemplated for the custom units supplied to the purchaser.

B. Installer Qualifications:
1. Subcontractor shall submit evidence of skill and not less than five years specialized experience with this product.

C. Mock-Up
1. Construct a mock-up sample, 3 meters (10 feet) square minimum, of the paving system, including the materials, pattern and joint treatment required in actual construction. Make mock-up samples as required until acceptance by the Architect. Consider the accepted mock-up as a minimum standard of workmanship to be matched or bettered throughout the Project. The sample may be constructed as part of the Project and, if approved, will be accepted as part of the Work. Remove samples which fail to meet the Architect's approval.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver and handle custom precast concrete pavers in such a manner as to prevent damage. Units shall be stored above ground on pallets. Pallets shall be clean and non-staining. All damaged or otherwise unsuitable material shall be immediately removed from the job site.

B. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.

1.8 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.
1. Do not work during freezing weather or on wet or frozen sub-base.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Fabricators: Wausau Tile Co., which is located at: P. O. Box 1520 9001 Bus Hwy. 51 ; Wausau, WI 54402-1520; Toll Free Tel: 800-388-8728; Tel: 715-359-3121; Email: request info (wtile@wausautile.com.); Web: www.wausautile.com

B. Approved equal.

2.2 PAVERS

A. Concrete Pavers: Custom fabricated.
1. Thickness: As indicated on Drawings.
2. Reinforcement: As indicated on Drawings.
3. Installation Patterns: As indicated on Drawings.
4. Color: Custom, Slate Gray-Black with sparkle provided by Black Beauty aggregate.
5. Finish: Heavy Sandblast finish or acid wash surface to meet performance.

B. Precast Material Requirements:
1. Precast Cementitious Materials: ASTM C 150 for Portland Cement.
2. Aggregates shall conform to ASTM specifications, except that grading requirements shall not necessarily apply, ASTM C 33 for concrete aggregates, normal weight.
   a. Exposed finish aggregate: Black or slate colored aggregates, maximum 1/8" - ¼" diameter.
3. Other Constituents: Coloring pigments, integral water repellents, etc., shall be previously established as suitable for use in concrete and either shall conform to ASTM Standards where applicable, or shall be shown by test or experience not to be detrimental to the durability of the concrete.
4. Retarder: Formula F by The Euclid Chemical Company, www.euclidchemical.co, 1-800-321-7628, or equal.
5. Coloring Admixture for integral color: ASTM C 979, inorganic, resistant to alkalinity and used per manufacturer's recommendations. Color by L.M Scofield Chromix: charcoal color, Butterfield Select Grade Color: gray or gauntlet gray color, or Solomon Dry Integral Color: taupe or lava color.
6. Sparkle aggregate: Black Beauty Aggregate, match gradation in Architect's sample.
7. Sealer: Colorless, pure acrylic water-repellent penetrating sealer. Sealer to maintain natural look of concrete surface with no glaze or gloss, darkening or color change.

C. Paver Performance Requirements:
1. Compressive Strength: At the time of delivery to the work site, the average compressive strength shall not be less than 5,000 psi with no individual unit less than per ASTM C 140.
2. Slip Resistance: For high traffic pedestrian use per ASTM F1637-10 Standard Practice for Safe Walking Surfaces.
3. Absorption: The average shall not be greater than 6 percent per ASTM C140.
4. Flexural Strength: Not less than 800 psi (5500 kPa) per ASTM 293.
5. Load carrying capacity: Paver units shall have a tested center load capacity of 1,850 lb (840 kg). WT CL96
6. Freeze/thaw: Durability of the paver shall meet the freeze/thaw tests in accordance with Section 8 of ASTM C67. Specimens, when tested, shall have no breakage and not greater than 1 percent loss in dry weight of any individual unit when subject to 50

cycles of freeze/ thaw.

7. Sizing: Permissible variations in dimensions shall not differ by more than 1/16 inch (1.6 mm) from width, height, length or thickness. Unit shall conform to a true plane and not differ by more than 1/16 inch (1.6 mm) in either concave and/or convex warpage.

2.3 INSTALLATION MATERIALS

A. Asphalt Setting Bed Materials:

1. Asphalt Cement: ASTM D 3381, viscosity grade AC10 or AC20.

2. Fine Aggregate: Clean, hard sand, free of organic matter, uniformly graded from coarse to fine, all passing the No. 4 sieve meeting the gradation requirements when testing in accordance with ASTM C 136.

3. Mixing: Provide plant mixed asphalt setting bed by combining dry fine aggregate (approximately 93 percent) and hot asphalt cement (approximately 7 percent) and heat to approximately 300 degrees F. Provide each ton of setting bed material apportioned by weight with the approximate ratio of 145 lbs. of asphalt to 1, 1885 lbs. of sand.

B. Setting Bed Primer: Cut back asphalt, ASTM D 2028, grade as recommended by the Asphalt manufacturer.

C. Asphalt Adhesive: Standard neoprene modified asphalt adhesive containing oxidized asphalt combined with 2% neoprene and 10 percent long fibered mineral fibers with a softening point of 155 degrees F.

D. Preformed Asphalt Joint Filler: ASTM D 994, 1/2 inch thick, for expansion joints which are not sealed, one of the following:

1. Code 1301, W.R. Grace & Co.; I.
2. Asphalt Expansion Joint, W. R. Meadows, Inc.
3. Elastite Asphalt Expansion Joint, The Celotex Corporation.

2.4 JOINTING SAND

A. HP Polymeric Jointing Sand by Techniseal. Color selected from Manufacturer's standard colors, dark range.

2.5 GEOTEXTILE FABIC

A. Filter Fabric

1. Synthetic, non-woven, needle-punched fabric that is resistant to chemicals and mildew, stable under freeze-thaw cycles, does not shrink or expand under wet conditions, does not unravel during use and meets the following criteria:

Property	Test Method	Results
Weight	ASTM D3776	136 g/sq. m (4 oz./sq. yd.) min.
Grab Tensile Strength (100 lbs.) min.	ASTM D4632	444 N

Mullen Burst	ASTM D3786	1448 kPa (210 psi) min.
Puncture Resistance	ASTM D4833	289 N (65 lbs.) min.
Trapezoidal Tear	ASTM D4533	178 N (40 lbs.) min.
Coefficient of Permeability	ASTM D4491	0.15 cm/sec. min.

B. Stabilization Fabric

1. Synthetic, woven fabric that is resistant to chemicals and mildew, stable under freeze-thaw cycles, does not shrink or expand under wet conditions, does not unravel or become clogged during use and meets the following criteria:

Property	Test Method	Results
Weight	ASTM D3776	153 g/sq. m (4.5 oz./sq. yd.) min.
Grab Tensile Strength	ASTM D4632	667 N (150 lbs.) min.
Grab Elongation	ASTM D4632	25 percent max.
Mullen Burst	ASTM D3786	2070 kPa (300 psi) min.
Puncture Resistance	ASTM D4833	423 N (95 lbs.) min.
Trapezoidal Tear	ASTM D4533	289 N (65 lbs.) min.
Coefficient of Permeability	ASTM D4491	0.01 cm/sec.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.

B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

C. Concrete shall not exceed 1/8 inch in 10 feet (3mm in 3 m) from required plane. Concrete to be steel troweled with fine broom finish. No curing or sealing compound used.

3.2 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Protection

1. Protect the work and adjacent construction against damage during progress of the Work.
   Do not use construction equipment which will damage existing or new pavement.

3.3 AGGREGATE BASE COURSES

A. Subgrade Preparation

1. Examine subgrade surfaces for line, grade, and compaction.
2. Bring subgrade surface found to be unsuitable up to grade and recondition as specified under Section, Site Earthwork, including the necessary fine grading, to ensure that the minimum specified depth of paving will bring the surface to the indicated elevations. If the Architect finds the subgrade surface unsuitable, such surface shall be struck off

with approved graders, scarified and wetted, and finally rolled with the addition of sufficient moisture to prevent drying out prior to the placing of the aggregate material.

3. Equipment
4. Equipment for construction of aggregate base courses is subject to approval by the Architect and shall be maintained in satisfactory working condition at all times.
5. Place the aggregate base courses by means of a moving vehicle equipped with spreader box, mechanical spreader, or other approved equipment capable of laying the courses so that the finished layer will be of the proper gradation and thickness.
6. Use compaction equipment consisting of self-propelled tamper or pneumatic-tired rollers or vibrating compactors, and three-wheeled or tandem rollers weighing from 5.4 to 9.0 tonnes (6 to 10 tons) and having a weight of between 3.6 and 5.8 kg per mm (200 lbs. and 325 lbs. per inch) width of roller. Use equipment which is capable of obtaining the required density throughout the entire depth of the layer being compacted.
7. Placing Aggregate
8. Place aggregate on the subgrade, using approved placing equipment, in a uniform layer to the required contour and shape and in layers not more than 100 mm (4 inches) (compacted) in thickness. Total thickness after compaction: minimum as indicated. Segregation of large or fine particles will not be acceptable; remove pockets of segregated material and replace with a satisfactory mixture, or remix as directed and approved by the Architect.
9. Compaction
10. After placing, compact the material by approved means. Begin rolling at edges of the area to be compacted and proceed towards the center. Compact areas not accessible to rollers by mechanical tampers.
11. Compact material to at least 95 percent of maximum unit weight. Maintain the moisture content within a tolerance of plus or minus 3 percent of optimum until the prescribed unit weight is obtained, as determined by ASTM D1557.
12. Compact each layer until the maximum unit weight is attained before placing the succeeding layer.
13. Density
14. During the construction of aggregate base courses, field density tests will be made as specified under Article Field Quality Control.
15. If density tests indicate that the base course does not comply with specified density requirements, additional wetting, if necessary, and rolling will be required until the specified density is obtained. Add moisture to the material during compaction only when it is necessary to increase the percentage of moisture to obtain the specified density.
16. Condition of Finished Surfaces
17. Smooth, even and true to the lines, grades and cross sections indicated. Maximum deviation of finished surface when tested with a 3-meter (10-foot) straight-edge parallel to the center line of the surfaced area: 6 mm (1/4 inch) in 3 meters (10 feet).

3.4 CONCRETE BASE SLAB

A. Install Concrete base slab in accordance with Section 32 13 13, Portland Cement Concrete Paving. Base slab provides rigid base for paver installation.

3.5 INSTALLATION OF BITUMINOUS SETTING BED

A. Place solid steel 3/4 inch thick control bars directly on the base or slab. Install shims under bars for minor adjustment of depth and finish paver elevations and slopes. Space bars approximately 11 feet apart and parallel to each other to serve as guides for strike-off boards.

B. Place asphalt setting bed at not less than 200 degrees F. in panels between control bars on the primed concrete slab or binder course to not less than 3/4 inch compacted thickness. Spread material and strike off by pulling the material with a 12 foot long x 2 inch x 6 inch wood board several times to produce a smooth firm and even setting bed. Add fresh material in low, porous spots after each pass of the strikeoff board. After each panel is complete remove and advance the first control bar to the next panel position in readiness for placing and striking adjacent panels. Fill in depressions left by the control bar and any shims.

1. If setting bed is installed greater than 1 1/2 inch thick, place in two equal lifts. Place the second lift immediately after the first to assure bond between lifts.
2. If pavers are not installed immediately after setting bed, provide protection of setting bed with minimum 1/2 inch plywood sheet laid on the setting bed with butted joints. Repair all damage to the setting bed prior to installing pavers.

3.6 SETTING PAVERS

A. PAVER AND SLAB INSTALLATION

B. Install precast concrete pavers, slabs and curbs in locations, patterns and at elevations and with slopes for surface drainage as shown on the Drawings. Install precast concrete pavers, slabs and curbs in accordance with the manufacturer's printed installation instructions and the final reviewed shop drawings.

C. Apply neoprene modified asphalt adhesive on the cured setting bed by squeegeeing or troweling. If troweled on, use a trowel with serrations not exceeding 1/16 inch depth. Place adhesive to not more than 1/16 inch thickness over the total surface of the setting bed. Do not begin installation of pavers, slabs and curbs until adhesive is dry to the touch. Neoprene adhesive only required at perimeter where no edge restraint exists.

D. Lay out pavement in 30 foot working area modules. Set precast concrete pavers, slabs and curbs by hand on dry adhesive in patterns shown on the drawings with hand tight joints 1/16 to 1/8 inch wide joints and uniform top surfaces.

E. Field cut precast concrete pavers in accordance with manufacturer's recommendations for methods, equipment and precautions.

F. Maintain accurate alignment and check for creep and shrinkage. Make adjustments to creep and shrinkage within the 30 foot module area.

G. Install polymeric jointing sand to fill joints immediately after installing pavers, slabs and curbs on setting bed per manufacturer’s instructions. Do not allow traffic on installed pavers, slabs or curbing until the joints have been filled.

H. Protect newly laid pavers, slabs and curbs with plywood panels on which workers stand. Advance protective panels as work progresses but maintain protection in areas subject to

continued movement of materials and equipment to avoid creating depressions or disrupting alignment of installed pavers, slabs and curbs.

I. Install the specified joint filler where precast concrete pavers, slabs and curbs abut curbs, other vertical surfaces and other construction.

J. Replace cracked or chipped precast concrete pavers, slabs and curbs at no additional cost to the Owner.

3.7 ALLOWABLE TOLERANCE

A. Finished surface: smooth, even, and true to the lines, grades and cross section indicated.

B. Maximum deviation of finished surface when tested with a 3-meter (10-foot) straight-edge parallel to the centerline of the surfaced area: 13 mm (1/2 inch) in 3 meters (10 feet).

C. Maximum offset from flush from paver surface to paver surface or from paver surface to a fixed flush edge: 1.6 mm (1/16 inch).

3.8 FIELD QUALITY CONTROL

A. Refer to Section 01 45 23.

3.9 REPAIR AND CLEANING

A. Remove and replace pavers which are chipped, broken, stained or otherwise damaged, or if units do not match adjoining units as intended. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment to eliminate evidence of replacement.

B. Clean concrete pavers after setting is complete; use procedures recommended by producer for types of application indicated.

3.10 CLEAN-UP

A. Sweep clean paved areas of excess sand and dirt.

B. Pick up and remove from the site surplus materials, equipment and debris resulting from the work of this Section.

3.11 PROTECTION

A. Provide final protection and maintain conditions which ensure paver work being without damage or deterioration at time of substantial completion.

END OF SECTION

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SECTION 32 91 00

SOIL PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies all soil materials designated as "Topsoil" or “Engineered Soil” on the Drawings or in the specifications. Supply topsoil for landscape work from on-site and off-site sources. Limited topsoil resources exist on site.

B. Related Sections
Earthwork - Section 31 20 00.
Turf Grasses - Section 32 92 10.
Native Seeding – Section 32 92 20.

1.2 REFERENCES

A. ASTM International, as referenced herein as ASTM.

B. US Department of Agriculture (USDA) Handbook No. 60 – Diagnosis and Improvement of Saline and Alkali Soils.

1.3 SUBMITTALS

A. Source Quality Control:
Material Test Reports: Conduct Topsoil testing for existing on-site surface topsoil.
Sample: Provide 1 quart samples for each topsoil test unit (including source).
Conduct all topsoil sampling and testing prior to prior to stripping and stockpiling from on-site sources.

B. Field Quality Control:
Submit field test reports as listed in Article 3.1.

1.4 QUALITY ASSURANCE

A. Qualifications:
Soil-Testing Laboratory Qualifications: The contractor shall engage an independent laboratory or university
laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Topsoil:
Topsoil for landscape work shall be a fertile, friable, silty clay loam surface soil without admixture

of subsoil
screened to be free of stones, stumps, root, trash, debris, and other materials deleterious to plant growth.

Particle Size Distribution of Topsoil:

Sieve Designation	Percent Passing
1 inch screen	100
1/4 inch screen	97 - 100
No. 10 U.S.S. mesh sieve	95 - 100
No. 140 U.S.S.	15 – 35

Percentages shall be based on dry weight of the sample.
The pH range shall be 6.5 to 7.6. Topsoil that does not meet this pH range shall not be approved by the
Landscape Architect.

Organic content shall not be less than 4 percent and not greater than 20%.

B. Sand :
1. On site IEPA approved waste sands, allowed for reuse in bioswale application.
2. Contractor shall verify with Laboratory locations of stockpiles where approved waste sands are located and shall maintain records as required by Laboratory and IEPA as to location and amount of sands utilized.
3. Sands will be supplied by Laboratory at no charge to Contractor.

2.2 PLANTING SOIL
A. Refer to Section 32 93 00/2.1.J.1 for preparation of planting soils for planting beds.

2.3 ENGINEERED SOIL (FOR USE IN BIOSWALE AREAS)

A. Planting Mix:

35% salvaged on-site topsoil
30 % compost (40%-60% OM content)
35% sand

2.4 SOURCE QUALITY CONTROL:

A. Laboratory Test Reports:
1. Conduct topsoil testing for each soil test unit as follows:
2. Existing on-site areas prior to stripping topsoil: 1 sample per acre of site to be excavated and/or each sub-area delineated by pavments, building and other site features that fragment the site into testing units less than 1 acre but larger that 0.25 acres in size.
3. Existing stockpile: 1 sample per 1,000 cubic yards of stockpiled soil.
4. Submit all test reports for Landscape Architect approval. Topsoil units that do not meet the soil requirements specified under this section will not be permitted for use as Topsoil.
5. Fertility: For each unamended soil type, test topsoil for organic materials, pH, phosphate, potash content, calcium, magnesium, zinc, iron, and manganese.

6. Physical Properties: Determine percent sand, silt and clay and textural classification (USDA) by hydrometer method. Identify all foreign materials such as rock, roots, and vegetation.
7. Supplemental Testing: Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action. If any heavy metal exceeds state listed background levels for human contact, soils will not be approved for use on site.
8. Recommendations: Based on the test results, the independent testing laboratory shall state recommendations for soil treatments and soil amendments to be incorporated. List recommendations in weight per 1000 square feet for turf area and volume per cubic yard of planting mix. Recommendations shall include; nitrogen, phosphorus, and potash nutrients and all soil amendments
to be added to produce the specified topsoil material satisfactory for the long-term growth of the specified plants and turf.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

A. Sampling: Each sample shall be a composite of five to seven subsamples taken the full depth of proposed source for each acre of surface area. For on-site stockpiles, discard upper 6 inches of soil before sampling. For large stockpiles, partial excavation will be required for collection of representative samples. Include site plan verifying the locations of all topsoil sampling. Topsoil test reports shall be accompanied with each sample unit for review and approval by the Landscape Architect.

B. Testing methods and written recommendations when not references elsewhere, shall comply with USDA's Handbook No. 60. Nutrient data to be given in parts per million (ppm) dry soil.

C. Topsoil shall be as defined in ASTM D5268.

D. Soil pH shall be tested in accordance with ASTM D4972.

E. Test for organic material by using ASTM D2974.

3.2 PLACING TOPSOIL

A. Topsoil Depths shall be as follows:
   1. Turf Grasses: min 6”
   2. Native Seeding Areas: min 8”
   3. Planting beds: 12”. Refer to Section 32 93 00 for preparation of topsoil and composition of planting soils for use in planting beds.

3.3 ENGINEERED PLANTING SOIL PLACEMENT

A. For bioswlae bio-infiltration planting areas: minimum 18” inch depth.

3.4 INSTALLATION OF ENGINEERED PLANTING SOIL

A. Prior to placement of engineered planting soil, verify that native soils or subsoils at rough grade are well draining. Conduct on-site testing to determine percolation rate.

B. Minimum on-site soils percolation rate should be 0.07” in 60 minutes.

C. Place engineered soil in 6” lifts and water settle. Do not mechanically compact.

D. Once engineered soils are placed, conduct on site testing to again determine percolation rate.

E. Minimum engineered planting soil percolation rate is 0.147” in 60 minutes. Amend engineered planting soil as needed with sand/compost to increase percolation rate, or topsoil/compost to decrease percolation rate. Retest until percolation is in acceptable range.

END OF SECTION

SECTION 32 92 10

TURF GRASSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes placing topsoil, finish grading, sodding lawn, and maintenance operations as indicated on plans and specified herein.

B. Related Sections:
1. Soil Preparation - Section 32 91 00
2. Native Seeding – Section 32 92 20
3. Planting - Section 32 93 00

1.2 REFERENCES

A. ASTM International, as referenced herein as ASTM.

B. Association of Official Seed Analysts, as refereced as AOSA.

1.3 SUBMITTALS

A. Product Data:
1. Seed Labels: Submit seed labels from bags showing mix composition.
2. Erosion control blanket, as specified in Section 31 2500 Soil Erosion and Sedimentation Control.
3. Fertilizer.
4. Pesticides and Herbicides.
5. Turf maintenance equipment.

B. Source Quality Control:
1. Samples:
   a. Sod – provide 3 samples of sod for approval prior to shipment of materials to the site.

   b. Erosion control blanket, as specified in Section 31 2500– provide 1 square yard section and anchor.
2. Test reports:
   a. Soil Preparation (See Section 32 91 00). Note: Topsoil is specified in this section.

C. Field Quality Control:
1. Maintenance Plan: Prior to the issuance of Substantial Completion, submit typewritten instructions for warranty maintenance of the entire landscape including schedules, irrigation, fertilization, pest and weed control, edging and trimming, and mowing. See Article 1.7 “Maintenance.” Coordinate turf maintenance with other applicable Sections (Planting, Native Seeding, Irrigation, etc.).
2. Maintenance Report Forms: Submit Maintenance Report Forms following completion of each maintenance visit identifying the maintenance work completed at the site. The forms

shall cross-reference the Maintenance Plan. Payment for this work will only be made by the Owner when proof of completed work has been provided.

3. Irrigation Plan: Submit a Watering or Irrigation Plan that outlines methods for maintaining seed bed moisture as described herein.
4. Schedule: Upon authorization to proceed with the work, submit three copies of construction schedule indicating dates for delivery and installation.

1.4 QUALITY ASSURANCE

A. Qualifications:
1. Installer: The work of this section shall be performed by a contractor specializing in sodding lawn installations and turf maintenance.
2. Turf Maintenance: The maintenance activities for all turf areas shall be performed by skilled employees of the landscape installer.

B. Regulatory Requirements:
1. All seed shall comply with applicable sections of the following references:
   a. Federal Seed Act
   b. AOSA “Rules for Testing Seed”.

C. Certifications:
1. Sod: Submit certification from proposed sod supplier that identifies turf species and proportions of each species in the sod, composition of the root zone in wich the sod has been grown, and date the sod was planted.
2. Pesticide Applicator: Provide information on state commercial pesticide business license and commercial pesticide application certification.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Contractor will protect sod against dessication, heating, contamination, and breaking during all stages of harvest, delivery and installation.

B. Sod shall be transported to site the day of installation and installed within twenty-four (24) hours after cutting. Sod delivered to the site in an enclosed vehicle will be rejected. Sod shall be stored at the site under shade in a moistened condition, protected from wind.

C. Fertilizers and other chemicals delivered to site must be in clearly labeled, unopened containers showing weight, analysis, and name of manufacturer.

1.6 SCHEDULING

A. Planting Season:
1. Sodding: Sod may be installed any time the ground is not frozen from April 15 through October 31.
2. Sodding outside the specified windows will only be permitted if approved in writing by the Landscape Architect prior to installation.

1.7 WARRANTY

A. Substantial Completion Inspection: Notify the Landscape Architect in writing when work is complete. Within 10 days after notification, the Landscape Architect will inspect the work and

prepare a Notice of Substantial Completion, along with a punchlist. The issue date of the notice will start the turf establishment period and the warranty period. This inspection will be conducted concurrently with the same inspection identified under Section 32 93 00 (Planting).

1. After receiving a Notice of Substantial Completion, establish and maintain all turf (see Article 1.7) in a vigorous, well-kept condition until Final Acceptance of the entire landscape, or no more than 2 months.

B. Final Inspection: Final Inspection and Acceptance will be at the end of the turf establishment period and shall be conducted concurrently with the final inspection of work covered in Section 32 93 00 (Planting). Acceptance will be based upon the required work having uniform finished grades conforming to the drawings and vigorous complete cover of the specified species, free of weeds, and/or conditions inconsistent with the installation specified. Areas which do not meet the contract requirements shall be regraded as needed and reseeded/resodded. The Contractor shall provide materials and labor necessary to correct any deficiencies as outlined during the warranty period. Repair rejected areas of turf within acceptable planting dates as directed by Landscape Architect.

1.8 MAINTENANCE

A. Provide full maintenance by skilled employees of landscape installer.

B. Begin maintenance immediately after each area is planted and continue until Final Acceptance of the entire landscape.

C. The approved Maintenance Plan shall serve as the basis for all maintenance activities. Detailed maintenance work reports shall be submitted to the Landscape Architect on a monthly basis for verification of completed work and documentation for payments to be made by the Owner.

D. Maintenance to include grade repair, irrigation, fertilization, reseeding or resodding, mowing, insect and weed control, trimming and edging. Roll, regrade, and replact bare or eroded areas and remulch to provide a uniformly smooth turf. Provide same materials and installation as those used in the original installation.

E. For sodded lawns wait at least 2 weeks for first mowing, checking first to ensure roots have taken hold. Mow when grass blades reach a height of 4 inches and mow to a height of 3 inches.

F. Sodded areas shall be rolled with a 200 pound roller within 30 days after installation.

G. Fill any depressions or settlement that occurs within maintenance period. Reseed or resod bare spots which occur during the maintenance period.

H. Irrigate sodded lawns as required to supplement natural rainfall so that all lawn areas receive sufficient water for normal plant growth, for a total minimum equivalent to 1 inch water per week. Infrequent but deep waterings promote deep root growth.

I. Where automatic irrigation system is not available, Contractor to provide all equipment needed for watering and be responsible for securing adequate supply of water. Water areas at a minimum rate equivalent to 1 inch of rainfall/week. Infrequent but deep watering promote deep root growth.

J. Fertilization:

1. Apply an initial starter fertilization 4 weeks after installation of lawn. Use the same analysis commercial fertilizer as recommended by soil test reports, or use 0.75 pounds of actual

nitrogen and 1 lb. P2O5 per 1000 square feet. The timing of this application may coincide with fertilizer applications given below and should replace the required formulation.

2. During the turf establishment period, fertilize lawns a minimum of three times during the growing season, once during each of the following dates:
   a. Late May, water-soluble slow-release fertilizer providing 1 lb. actual nitrogen per 1,000 square feet.
   b. Mid-September, complete quick-release fertilizer providing 1 lb. actual nitrogen per 1000 square feet.
   c. Late October, complete quick-release fertilizer providing 1.5 lb. actual nitrogen per 1000 square feet.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Sod
1. Provide an Approved Number 1 Quality/Premium sod, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turgrass Sodding". Furnish sod comprised of a blend of at least 4 Kentucky bluegrass cultivars, of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development once planted. Sod shall be 2 years old and shall have been grown at a sod nursery in a mineral-based root zone. Sod grown on peat (organic soil) will not be approved. Sod shall be free of objectionable grassy and broad leaf weeds.
2. Thickness and width of sod shall be kept to strict dimensions, with width being 24 inches and containing 90-degree angle cut edges. Netting associated with harvest must be removed before installation.

B. Straw Mulch
1. Provide stalks from oats, wheat, rye, barley or rice that are free of weeds, mold or other objectionable material.
2. Straw shall be in an air dry condition and suitable for placing with commercial mulch blowing equipment.

C. Fertilizer
1. Fertilizer shall be a complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, not less than 30% of the nitrogen from a slow release source. Fifty percent of the nitrogen shall be derived from natural organic sources. The percentages by weight shall be determined per recommendations of the soil testing reports for lawns.

D. Erosion Control Blanket
1. Type as noted in Drawings or TRM, as defined in Section 31 2500 Soil Erosion and Sedimentation Control .

PART 3 - EXECUTION

3.1 EXAMINATION

A. Contractor must examine the areas and conditions under which all items are to be installed and notify the Landscape Architect in writing of conditions detrimental to the proper and timely completion of the work. Lawn installation will not proceed until unsatisfactory conditions have been corrected in a manner acceptable to the Landscape Architect.

B. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.

C. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.

D. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

3.2 INSTALLATION

A. Grade Preparation
1. Maintain rough grades in the areas to be topsoiled in a uniform condition so as to prevent future depressions. Prior to placing topsoil, repair disturbances to previously graded areas and remove surplus subgrade material associated with any landscape construction. Scarify areas to a depth of 6 inches prior to topsoil placement. Scarifications shall have a maxiumum 2 foot separation and be cut in two directions, one perpendicular to the other.
2. If the prepared grade is eroded or compacted by rainfall prior to fertilizing, rework the surface as specified. Remove stones larger than 1 inch in any dimension and stickes, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
3. Soil Amendments:
   a. Amend soil with lime or sulfur as recommended by soil tests, working it into the top 4 inches of soil at same time as fertilizer application.
4. Fertilizer:
   a. Uniformly distribute fertilizer by mechanical means at the rate recommended by soil tests.
   a. Uniformly distribute fertilizer by mechanical means at the rate of 10 pounds of 10-10-10 per 1000 square feet (to make 1 pound of actual nitrogen per 1000 square feet).
   b. Work fertilizer into the top 4 inches of soil. Cultivating equipment shall be set so that the fertilizer will not penetrate into the soil more than 4 inches. Do not apply fertilizer when there is a possibility of rain before lawn areas can be seeded.

B. Placing Topsoil
1. Uniformly distribute topsoil on lawn areas so that after compaction and finish grading, topsoil depth is (8".) Reduce elevation of planting soil to allow for thickness of sod. Placement shall include spreading, cultivating, lightly compacting, dragging and grading to the conditions specified below.
2. Topsoil, when placed, shall be dry enough so as not to puddle or bond. Do not place topsoil when the subgrade is frozen, excessively wet, extremely dry or in a condition otherwise detrimental to proper grading or lawn operation.
3. Immediately before sodding scarify, loosen, float, and drag topsoil as necessary to bring it to the proper condition. Remove all foreign matter larger than 1 inch in diameter.

C. Finished Grades
1. Finished grades shall slope to drain, be free of depressions or other irregularities after thorough settlement and compaction of soil, and shall be uniform in slope between grading controls and the elevations indicated.
2. Finished grade for sodded lawn areas shall meet existing grades at contract limits and be 1 inch below top of curbs, walk paving, and metal edging if used.

D. Sodding
   1. Lay sod end to end and in a double row parallelling all hardscape edges adjacent to new lawn area. This does not apply to areas near roadway with aggregate shoulders adjacent to seeded lawn areas.
   2. Correct all inequalities and soft spots in the lawn bed before the sod is laid. Weed roots, if any, must be removed before the sod is laid. Roll site with a 200 pound roller to firm the soil. Sod must be installed onto moist soil. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
   3. Lay sod to form a solid mass with joints staggered so that no voids occur between the strips. Butt ends and sides of sod rolls; do not overlap and do not stretch sod to make edges meet. Stagger rolls to offset joints in adjacent courses. Lay sod across angle of slopes exceeding 3:1, and anchor sod on slopes exceeding 2:1 or steeper with two 8-inch stakes per square yard. Tamp or roll sod immediately after it is laid to ensure contact with the topsoil. Work sand or topsoil into minor cracks between pieces of sod and remove excess to avoid smothering adjacent sod. The finished surface shall be true to grade and shall be smooth, even, and equally firm at all points.
   4. Begin watering sod within 30 minutes of installation and water daily for the first two weeks; twice a day in hot dry weather. Keep soil in sodded areas moist but not soaked to 1.5 inches below sod. After the sod is completely installed, resod all areas which have browned out or fail to show a uniform stand of grass. Repair all visible cracks between sod.

3.3 REPAIR/RESTORATION

A. Paved areas over which hauling operations have been conducted shall be kept clean. Promptly remove materials spilled on pavement.

B. Upon completion of lawn installation, remove from the site and legally dispose of the following:
   1. Surplus subgrade material.
   2. Stone and foreign matter.

C. Excess topsoil not required for lawns or planting shall be stockpiled on site for future use as directed by the Owner.

D. Repair existing lawns damaged by operations under contract. Repair shall include finish grading, seeding or sodding as required to match existing grade and lawn, and maintenance of repair areas.

END OF SECTION

SECTION 32 92 20

NATIVE SEEDING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Procurement, scheduling, installation, maintenance, and warranty of meadow seeding and native prairie seeding of wet, wet mesic, and upland areas in accordance with the plans and as specified herein.

B. Related Sections:
1. Section 32 91 00, Soil Preparation, which includes topsoil requirements and preparation of bioswale planting soils.
2. Section 31 25 00, Soil Erosion and Sedimentation Control.

1.2 REFERENCES

A. Association of Official Seed Analysts, as referenced as AOSA.

1.3 SUBMITTALS

A. Product Data:
1. Within 4 weeks following the issuance of the Notice to Proceed, submit name and location of seed supplier(s) and a complete list of each seed mix by weight and proportion that is being supplied before the seed mix is ordered. Substitutions will not be permitted.
2. Geographic origins of each seed species.
3. Method of seeding, including all equipment to be used and manufacturer's specifications for care and handling.
4. Tackifier: manufacturer's specifications and recommended rates of application.
5. Erosion control blankets, including anchor.
6. Mycorrhizal inoculum: manufacturer's specifications and recommended rate of application.

B. Source Quality Control:
1. Samples:
   a. Straw mulch – one bale.
2. Erosion control blanket – provide 1 square yard section.
3. Certifications:
   a. Test Reports: Prior to delivery of products to the site, submit the following:
   b. Seed viability: Pure Live Seed (PLS) test reports for each species; tetrazolium (TZ) testing only conducted by a qualified independent testing laboratory.
   c. Seed purity: test reports for each species.
   d. Topsoil: two copies each of certified test reports for soil preparation (Section 32 91 00).
   e. Seed Source (location.)

C. Field Quality Control:

1. Maintenance Plan: Prior to the issuance of Substantial Completion, submit detailed methodology and schedules for warranty maintenance of native seeded areas including irrigation, weed control, and invasive species eradication. See Article 1.7 "Maintenance". Coordinate native seeding maintenance with other applicable Sections (Turf Grasses).
2. Maintenance Report Forms: Submit Maintenance Report Forms following completion of each maintenance visit. The forms shall cross-reference the Maintenance Plan. Payment for this work will only be made by the Owner when proof of completed work has been provided.
3. Irrigation Plan: Submit Watering or irrigation plan that outlines methods for maintaining seed bed moisture as described herein. Reliance on natural precipitation will only be allowed with provision of recorded data from a rain gauge located within 1-mile of the project site.
4. Schedule: Within 4 weeks following the issuance of the Notice to Proceed, submit a project work schedule to the Landscape Architect indicating the dates of each of the following events:
   a. Seed installation – verify compliance with seeding schedules for each mix.
   b. Substantial Completion of work – verify compliance with seeding schedules for each mix.

1.4 QUALITY ASSURANCE

A. Qualifications:
1. Many of the wildflower seed species identified in the seed mixes included in this Section will require field collection, cleaning, drying and storage. This is a specialized operation that requires a thorough knowledge of:
   a. Native species identification.
   b. Seed maturation periods.
   c. Seed testing and germination requirements.
   d. Cleaning, drying, storage, and mixing procedures.
   e. Seed installation.
2. The work of this section (installation and maintenance) shall be performed by a Contractor specializing in native seeding.

B. Regulatory Requirements:
1. All seed shall comply with applicable sections of the following references:
   a. Federal Seed Act.
   b. Association of Official Seed Analysts (AOSA): "Rules for Testing Seed".
   c. Plants of the Chicago Region, by Swink and Wilhelm, current printing.

1.5 DELIVERY, STORAGE, AND HANDLING

A. All seeds shall be packaged and kept dry to ensure adequate protection against damage and to maintain dormancy while in transit, storage, or during planting operations.

B. All seed shall be delivered to the site in sealed containers and labeled, in compliance with the Federal Seed Act and applicable State laws.

C. Seed shall not be delivered and stored longer than 9 months before installation.

D. Herbicides and other chemicals delivered to site must be in clearly labeled, unopened containers showing weight, analysis, and name of manufacturer.

E. Straw mulch shall be stored off the ground under a cover that provides protection from moisture and humidity.

1.6 SCHEDULING

A. Seeding Season
   a. Seeding of Wet-Mesic and Upland Prairie Seed Mix shall occur during the dormant winter months – November 15 through February 15. Seeding for Meadow Seed shall occur as specified in IDOT guidelines.
   b. Do not apply onto snow-covered ground.
   c. If the site is final graded before the dormant season, following final grading approval, stabilize the site until seeding can occur with an erosion control seed mix consisting of 32 pounds of seed oats *(Avena sativa)* and 5 pounds of annual rye *(Lollium multiflorum)* per acre. Or, install winter wheat *(Triticum aestivum)* from September 1 through October 15 at a rate of 20 pounds per acre.

1.7 WARRANTY

A. Substantial Completion:
   1. Following Native Seed Mix installation, the Landscape Architect and Contractor shall conduct a Substantial Completion Inspection on all seeded areas. Following this inspection, re-topsoil, reseed, mulch, and re-apply erosion control blankets or turf reinforcement matting as directed by the Landscape Architect. Bare spots greater than 5 square feet shall be reseeded in accordance with the original specifications. All repairs shall be completed within one week following the inspection. All reseeding shall occur at no additional cost to Laboratory.

B. Final Acceptance:
   1. Final Acceptance will be granted one full year following installation of the Native Seed mixes dependent on achieving specification requirements. Final Acceptance shall be defined as an even distribution and germination of cover crop and an indication of specified native seedlings across the project site. There shall be clear evidence that the specified maintenance mowing has occurred to control weed species. Bare spots greater than 5 square feet shall be reseeded in accordance with the original specifications. All reseeding shall occur at no additional cost to the Owner. Failure to meet the requirement shall result in the Contractor extending the maintenance period until the specified cover is achieved at no additional cost to Laboratory.

1.8 MAINTENANCE

A. Native Seed Mix:
   1. During the first growing season following seeding, mow the native seeded areas each time (up to 4 times) that the plant material (annual and perennial weeds) has reached a height of 12 – 16 inches tall. Mow to a height of 4 – 6 inches. A flail-type mower that will finely shred mowed clippings must be used. Alternatively, a string trimmer may be utilized but all clippings and seed heads must be removed from the site following cutting.
   2. Do not hand-pull any plants the first year following seeding because such action could disrupt small native seedlings.

3. Spot treatment of weeds with an appropriate herbicide must be executed by a certified pesticide applicator using the wick or soaked-glove methods only. Follow all manufacturer label directions, including timing, mixing, application, and clean-up.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Seed:
1. Origin:
a. All seed material shall originate from local sources within 100 miles of the project site, to the extent possible, specifically from USDA Plant **Hardiness Zone 4** or lower.
2. Quality:
a. Seed shall be fresh, clean, dry, new-crop seed tested for minimum percentages of purity and germination.
b. No substitutions of seed will be allowed.
3. Testing Requirements:
a. The seed weights noted under Article 2.1A.5 of this section indicate weight per acre in Pure Live Seed (PLS) and shall mean the total amount of fresh new crop seed per acre for all species listed. All test results for purity and vitality shall be completed and submitted in advance of seed installation. Based on these results, the Contractor will be required to provide supplemental seeding for each species that does not meet the specified rates of PLS.

4. Seed Suppliers:
a. Cardno J.F. New Native Plant Nursery at nurserysales@jfnew.com or 574.586.2412.
b. Genesis Nursery, Inc., 23200 Hurd Rd., Tampico, IL 61283, 815-438-2220.
c. Ion Exchange, www.ionxchange.com or 800-291-2143.
d. Prairie Moon Nursery, www.prairiemoon.com or 866-417-8156.

5. Seed Mix Composition:
a. Wet-Mesic Prairie Seed Mix.

Wet-to-Mesic Prairie Seed Mix

Botanical Name	**Common Name**	**PLS Ounces/Acre**
Permanent Grasses:		
Andropogon gerardii	Big Bluestem	24.00
Calamagrostis canadensis	Bluejoint Grass	1.00
Carex spp.	Prairie Sedge Mix	4.00
Carex lurida	Bottlebrush Sedge	2.00
Elymus virginicus	Virginia Wild Rye	24.00
Panicum virgatum	Switch Grass	2.00
Scirpus pendulus	Red Bulrush	0.25

Sorghastrum nutans	Indian Grass	6.00	
Spartina pectinata	Prairie Cord Grass	3.00	
	Total	**66.25**	
Temporary Cover:			
Avena sativa	Common Oat	360.00	
Lolium multiflorum	Annual Rye	100.00	
	Total	**460.00**	
Forbs:			
Aster novae-angliae	New England Aster	0.25	
Baptisia lactea	White Wild Indigo	0.75	
Chamaecrista fasciculata	Partridge Pea	2.00	
Coreopsis lanceolata	Sand Coreopsis	3.50	
Coreopsis tripteris	Tall Coreopsis	3.00	
Desmodium illinoiense	Illinois Tick Trefoil		0.50
Echinacea purpurea	Broad-Leaved Purple Coneflower		3.50
Eryngium yuccifolium	Rattlesnake Master		2.00
Helenium autumnale	Sneezeweed		2.50
Helianthus grosseserratus	Saw-Tooth Sunflower		0.50
Lespedeza capitata	Round-Headed Bush Clover		1.50
Liatris spicata	Marsh Blazing Star		1.00
Monarda fistulosa	Wild Bergamot		1.00
Parthenium integrifolium	Wild Quinine		1.00
Physostegia virginiana	Obedient Plant		0.25
Pycnanthemum virginianum	Common Mountain Mint		1.00
Ratibida pinnata	Yellow Coneflower		5.00
Rudbeckia hirta	Black-Eyed Susan		5.50
Rudbeckia laciniata	Wild Golden Glow		1.00
Rudbeckia subtomentosa	Sweet Black-Eyed Susan		0.50
Silphium integrifolium	Rosin Weed		1.00
Silphium laciniatum	Compass Plant		2.00
Silphium perfoliatum	Cup Plant		3.00
Silphium terebinthinaceum	Prairie Dock		6.00
Solidago juncea	Early Goldenrod		0.25
Solidago rigida	Stiff Goldenrod		1.00
Solidago rugosa	Rough Goldenrod		0.25
Tradescantia ohioensis	Common Spiderwort		1.25
Veronicastrum virginianum	Culver's Root		0.25
Zizia aurea	Golden Alexanders		0.50

Total	**61.75**

b. Meadow Seed Mix: IDOT Mix 1B, Low Maintenance Lawn Mixture.
c. Upland Prairie Seed Mix: IDOT Mix #4, Native Grass.
d. Wet Prairie Seed Mix: Sedge Meadow Seed Mix by Cardno J.F. New.

B. Topsoil and Engineered Planting Soils:
1. Topsoil for seeding shall be on-site topsoil supplementing with off-site topsoil if needed.
2. Engineered planting soils for bioswale seeding shall be as specified in 32 91 00 Soil Preparation.

C. Mulch:
1. Straw:
a. Provide stalks from oats, wheat, rye, barley, or rice that are free of weeds, mold, and other objectionable material.
b. Straw shall be in an air-dry condition and suitable for placing with commercial mulch-blowing equipment.

D. Tackifier:
1. Binding agent used to hold straw mulch material in place shall be a clear non-staining latex-based tackifier or a water-soluble polymer.
2. Asphalt emulsion adhesive is not permitted.

E. Mycorrhizal Inoculum:
1. The inoculant shall contain highly selected strains of low host specificity endo- and ectomycorrhizal fungi combined with other beneficial fungi (Trichoderma), humic acids, biostimulants, beneficial bacteria, soluble sea kelp, and yucca plant extracts. Endomycorrhyzal fungi shall be available as propagules, i.e., spores, root fragments and hyphae.

F. Erosion Control Blanket:
1. For slopes greater than 4:1: Biodegradable double net with straw mulch matrix such as North Amercan Green S150BN .
2. For weir overflows in bioswales: Biodegradable double net with straw-coconut mulch matrix such as North Amercan Green SC150BN .

G. Fertilizer:
1. Fertilizer is not required for native seeding.

H. Water:
1. Water shall be free of wastewater effluent or other hazardous chemicals. On-site sources of water may not be available. Confirm prior to commencing work.

2.2 EQUIPMENT

A. Drop seeder/spreader with cultipacker, such as Brillion or John Deere.

B. Hydroseeding will not be permitted for native seeding.

C. Crimping Device:
   1. A mulch disc or other mechanical anchoring/crimping device for use in anchoring straw mulch into place, such as a Reinco Model MD-96 or equivalent, with flat discs with notched edges spaced 8 inches apart to impress mulch 1 – 3 inches down into soil.
   2. Crimping device (serrated disk) is an acceptable alternative to the Tackifier and is the preferred method of anchoring.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Upon authorization to proceed with the work, the Contractor shall examine and verify the acceptability of the job site. Notify the Landscape Architect if conditions detrimental to plant growth are encountered such as rubble fill, adverse drainage conditions, or obstructions. Do not proceed with the work until unsatisfactory conditions have been corrected or resolved in writing by the Landscape Architect.

B. Coordination is required to ensure rainfall/groundwater seepage does not result in soil moisture conditions that will cause excessive rutting during seeding and mulching operations. Failure to meet this requirement will not be an acceptable reason for not installing the seed as specified.

C. Where seeding occurs in close proximity to other site improvements or areas to remain undisturbed such as existing wetlands and uplands areas, care shall be taken to not disturb the existing conditions. Any areas damaged during planting operations shall be promptly restored to their original condition at no cost to the Owner.

3.2 PREPARATION

A. Immediately following contract award, the Contractor shall begin seed procurement. During the four week procurement period, the Contractor shall locate all seed suppliers, collectors and producers and set up supply contracts to ensure that the quantity and quality of seed material will be available during the specified planting window.

B. Any species substitutions MUST be approved by the Landscape Architect prior to seed procurement.

3.3 INSTALLATION

A. General:
   1. Do not sow seed during adverse weather or when wind speeds exceed five miles per hour.
   2. Do not sow seed in areas where standing water is present.

B. Grade Preparation:
   1. Subgrade and finish grade preparation shall be in accordance with site earthwork requirements, and topsoil shall be a minimum (8) inches deep after light compaction to prevent settlement.
   2. Prior to seeding, repair any ruts, rills, or gullies greater than 2 inches in depth to create smooth continuous grades.
   3. If the prepared grade is eroded or compacted by rainfall or other reasons, rework the topsoil to the full (12)-inch depth.

4. Immediately before seeding, scarify, loosen, float and drag topsoil as necessary to bring it to the proper condition. Remove foreign matter larger than 1-inch diameter.
5. No further grade preparation is required.

C. Layout:
1. All seeding zone boundaries shall be surveyed and staked on the project site by the Contractor. No seed mix shall be installed until the grade preparation and layout have been approved by the Landscape Architect.
2. The Landscape Architect reserves the right to adjust seed limits without adjusting total seeded areas, to meet field conditions, at no additional cost to Laboratory.

D. Method:
1. Hand-broadcasting:
   a. For dormant seeding, the plant material from the previous growing season shall be cut to at least 6 inch height and cut material removed to allow the broadcast seed to make good soil contact. Seed can be sown directly into the cut plant stubble.
   b. For spring seeding, sew seed directly onto bare ground or ground where the previous year's plant stubble has been cut to 2 inch height.
   c. Increase the volume of the broadcasted seed mix by mixing it with an approved carrier. Acceptable carrier material includes moistened compost, peat moss, or coarse-grade vermiculite. Sand and sawdust are unacceptable carrier materials. Use one bushel basket of carrier per 1,000 square feet of area to be seeded (a bushel equals 8 gallons or 1.24 cubic feet).
   d. Use 1/2 total seed mix and cross the entire area to be seeded, evenly spreading the seed. Walk perpendicular to the original seeding and evenly broadcast the second half of the seed mix.
   e. Light seeds, awned seeds, or bearded seeds tend to rise to the top of the spreader, therefore, mix seed accordingly as planting commences.
   f. Rake or drag the seed into the soil, but not more than 1/4-inch deep. Roll the area with a roller to firm the seed into the soil. Rolling is not necessary on dormant seedings.
1. Drill Seeder or Drop Seeder/Spreader:
   a. For dormant drill seeding, the plant material from the previous growing season should be cut to at least 6 inch height and cut material removed to allow the broadcast seed to make good soil contact. Seed can be sown directly into the cut plant stubble.
   b. For dormant drop seeding, the previous year's plant material should be cut and the ground cultivated before installing seed mix.
   c. For spring drill seeding, sew seed directly onto bare ground or ground where the previous year's plant stubble has been cut to 2 inch height; for spring drop seeding, cultivate the ground before installing seed mix.
   d. If using a drill seeder and there are separate native grass and forbs seed mixes, remove delivery tubes when installing the forbs mix and allow the seeds to drop directly from the box.
   e. Check the equipment frequently to ensure the seed is dispersing evenly and is not clogging.
   f. If the equipment is not equipped with a roller, pass over the seeded area with a roller to firm the seed into the soil. Rolling is not necessary with dormant seeding.
   g. Do not mix the native seed with any carrier material.
   h. Evenly distribute the seed across the entire site to be seeded.

2. **Keep the topsoil moist (to a depth of 3 inches) for 3-6 weeks following seeding**; afterward, apply 1inch water during the growing season if rain has not occurred for more than one week. Do not apply water with such a force as to disturb seed, seedlings, and/or topsoil, or that would run off soil surface.

E. Mulch:
1. Spread straw mulch evenly at the rate of 2 tons per acre over the native upland seeded areas. Place all mulch on given areas within 48 hours after seeding. A mechanical blower may be used to apply mulch material, provided the machine has been specifically designed and approved for this purpose. Anchor all mulch using as specified. If a spraying tackifier is used, it may be applied either simultaneously or in a separate application. Apply tackifier over all mulched areas at a rate recommended by manufacturer.

F. Erosion Control Blanket:
1. Install erosion control blanket as indicated in details on the Plans on all areas specified to receive it.
2. Immediately following seeding, erosion control blanket shall be rolled out in place in the direction of the slope fall line. The material shall be applied without stretching and shall lie smoothly but loosely on the soil surface. Installers shall minimize walking directly on the seed or topsoil bed either before or after the blanket is applied.
3. All ends shall be buried a minimum of 4 inches deep and the trench shall be firmly tamped after closing.
4. In cases where roll ends join, the up-slope piece shall overlap the down-slope piece by at least 18 inches.
5. Staple edges prior to backfilling trench, all overlaps at 12-inch intervals, and the center of each panel on 3-foot intervals.
6. The upslope ends of the blanket shall be buried a minimum of 6 inches deep and stapled at 12-inch intervals prior to backfilling trench.
7. Reseed all disturbed edges immediately following straw blanket installation and work seed into blanket.
8. Restore or reinstall Phase 2 silt fence if disturbed during seeding and blanketing operations.

3.4 REPAIR/RESTORATION

A. All areas over which hauling operations have been conducted shall be kept clean on a daily basis. Promptly remove all materials spilled on pavement.

B. Upon completion of seed installation, remove from the site and legally dispose of all trash and debris including any material removed during grade preparation.

C. Restore any existing areas damaged by operations under the contract. Restoration shall include finish grading and seeding as required to match existing grade and/or wetlands, and maintenance of restored areas.

D. Any damage by the Contractor to established or newly seeded areas not within the project scope of work shall be repaired and reseeded at no cost to the Laboratory.

END OF SECTION

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SECTION 32 93 00

PLANTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Landscape planting shall include the supplying of all materials and completion of all work items associated with the installation, warranty, and maintenance of all trees, shrubs, ground cover, and perennials shown on the plans and specified herein. Section also includes gravel mulch used in maintenance strip installation and contrasting gravel mulch areas, splash pad installation.

B. Landscape Boulders and Ledge Stone as specified in Drawings.

C. Related Sections:
1. Section 02 10 50, Tree and Plant Protection.
2. Section 31 10 00, Site Preparation and 31 10 10, Landscape Site Preparation.
3. Section 31 25 13, Soil Erosion and Sedimentation Control.
4. Section 32 91 00, Soil Preparation.
5. Section 39 92 10, Turf and Grasses.
6. Section 32 92 20, Native Seeding.
7. Section 33 46 00, Subdrainage.

1.2 REFERENCES

A. Hortus Third, The Staff of the L.H. Bailey Hortorium. 1976. MacMillan Publishing Co., New York.

B. ASTM International, as referenced herein as ASTM.

C. ANSI Z60.1, current version, American National Standards Institute, as referenced herein as ANSI.

1.3 SUBMITTALS

A. Product Data:
1. Invoice: Submit vendor invoice or bill of lading for each plant shipment showing sizes, quantities and root treatment.
2. Tree wrap.
3. Soil amendments: Provide information on composition and source of all soil amendments.
4. Fertilizer.
5. Pesticides and Herbicides: Include product label and manufacturer’s application instructions specific to the project site.
6. Antidesiccants: Include product label and manufacturer’s application instructions.
7. Filter fabric, as specified in 31 25 00 Soil Erosion and Sedimentation Control.
8. Mulch.
9. MSDS sheets for any chemicals used.
10. Samples: Gravels for selection and plastic edging utilized for maintenance strip.

B. Source Quality Control:
   1. Samples: Provide representative samples to the Landscape Architect of the following materials from the supply source being proposed:
      a. Plant Material:
         1) Sources and nursery purchase order agreements for each specified plant.
         2) Inspection and tagging may be completed by Landscape Architect for compensation.
         3) Plant samples or digital photos of plants may be requested in lieu of inspection. Photos must depict the entire size and condition of the plant and include a scale rod or other measuring device to show scale. For species where more than 20 plants are required, include a minimum of three photos that show the average plant, the best quality plant, and the worst quality plant to be provided. Label each photograph with the plant name, plant size, and name of the growing nursery.
      b. Mulch, Organic and Inorganic: 1 quart by volume in sealed plastic bag labeled with composition of materials by percentage of weight and source of mulch. Inorganic Mulch samples for selection.
      c. Erosion control blanket – 1 square foot.
      d. Staking and/or guying materials.
      e. Tree wrap – 3 foot section.
      f. Filter fabric – 1 square foot.
   2. Test Report:
      a. Topsoil: two copies each of certified test reports for Soil Preparation (Section 32 91 00).
   3. Certifications:
      a. Phytosanitary certification: Plant material Inspection Certificates required by Federal, State or other governing authority shall be submitted to the Landscape Architect upon delivery of each shipment.
      b. Analysis and standards: Products in sealed containers shall be labeled with manufacturer's certified analysis. Bulk materials shall be tested by an approved laboratory in accordance with Association of Official Agricultural Chemists procedures, or as specified by product specifications referenced herein.

C. Field Quality Control:
   1. Maintenance Plan: Prior to the issuance of Substantial Completion, submit detailed typewritten methodology and schedules for warranty maintenance of all landscape activities outlined in Article 1.7 of this section. Coordinate landscape maintenance with other applicable Sections (Native Seeding, Turf Grasses). The schedule shall be comprehensive and shall be the basis for monthly payment during the maintenance period.
   2. Maintenance Report Forms: Submit Maintenance Report Forms following completion of each maintenance visit. The forms shall cross-reference the Maintenance Plan. Payment for this work will only be made by the Laboratory when proof of completed work has been provided.
   3. Irrigation Plan: Submit watering or irrigation plan that outlines methods for maintaining landscape as described herein. Reliance on natural precipitation will only be allowed with provision of recorded data from a rain gauge located within 1-mile of the project site.
   4. Schedule: Within 4 weeks following the issuance of the Notice to Proceed, submit a project work schedule to the Landscape Architect indicating dates for delivery, installation, and Substantial Completion.

1.4 QUALITY ASSURANCE

A. Qualifications:
   1. The Contractor shall be a company specializing in landscape installation and maintenance, having minimum 3 years experience in projects of the scope and scale being specified.

B. Substitutions:
   1. Substitutions of plant materials will not be permitted unless authorized in writing by the Landscape Architect. If proof is submitted in writing that a plant specified is not obtainable, the Landscape Architect may assist in identifying alternate sources or substitutions. Plants of larger size may be used if approved and if root balls meet ANSI/AAN standards for the increased size. Adjustments will be made at no additional cost to the Owner.
   2. Container plants may be substituted for those designated "B&B" if approved by Landscape Architect.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General:
   1. Packaged Materials: Deliver packaged materials in original unopened containers showing weight, analysis and name of manufacturer. During shipment and storage on site, protect materials from breakage, moisture, heat or other damage.
   2. Store materials only in locations approved by the Owner.

B. Plant Materials:
   1. Schedule shipping to minimize on-site storage of plants. Stock shall not be shipped until the planting preparations have been completed. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. During shipment, do not bend, stack or bind plants in a manner that damages bark, breaks branches or root systems, deforms root balls or destroys natural shape. Transport plants in closed vehicles or with the entire load properly covered to protect from drying winds, heat, freezing or other exposure that may be harmful.
   2. Labels: Prior to shipping, each plant or bundle of like variety and size shall be labeled with legible weatherproof tags indicating the correct name and size of plant.
   3. Once on site, keep plants thoroughly watered and protected from sun, wind and mechanical damage; completely cover root balls with moistened topsoil or mulch. Water as often as necessary to maintain root systems in a moist, but not overly wet, condition.
   4. Handle plants at all times in accordance with the best horticultural practices. Lift B&B materials from the bottom of the ball only; do not roll the plants. Plants handled otherwise will be subject to rejection. Balled and burlapped plants which have cracked or broken balls are not acceptable and shall not be planted. Plants with mechanical damage, deformation or breakage will not be accepted and are to be replaced at the Contractor's expense.

1.6 SCHEDULING

A. Work Schedule:
   1. Upon authorization to proceed with the work, submit a project work schedule indicating the dates of each of the following items:
      a. Tagging of plants in nurseries.
      b. Delivery of other materials to the site.
      c. Staking of plant locations on the site.
      d. Delivery of plant material to the site.

e. Planting.
f. Substantial Completion of the work.

2. Update schedule at least monthly to reflect progress of the work.

B. Planting Season:

1. Materials shall be installed during planting seasons normally recognized in the job locality.
   a. Planting Restrictions:
   b. All Oaks (Quercus) excepting Swamp White Oak (Quercus bicolor): Spring only.
   c. Hornbeam (Ostrya): Spring only.
   d. Kentucky Coffeetree (Gymnocladus): Spring only.
2. Planting season shall be from April 15 to June 30 and from October 1 until the prepared soil becomes frozen in USDA Hardiness Zone 4. Plant evergreen plants between April 15 and June 15. When unusual planting conditions exist or when container-grown material is used, the Landscape Architect may alter these planting seasons.
3. If special circumstances warrant installation outside the normal planting season, submit a written request to the Landscape Architect describing conditions and stating the proposed variance. Planting outside the planting season does not alter warranty obligations.

1.7 WARRANTY

A. Substantial Completion:

1. Notify the Landscape Architect in writing when planting is complete. Within 10 days after notification, the Landscape Architect will inspect the work and prepare a Notice of Substantial Completion, along with a punchlist of items that require completion or correction. Issuance of the Notice of Substantial Completion shall constitute the start of the warranty period for portion accepted. All plant materials shall be maintained in a vigorous condition against all defects including death, improper maintenance, and unsatisfactory growth for one year following completion of plant installation except for fall plantings, when the warranty period will end October 15.
2. The Contractor will not be responsible for defects resulting from neglect by Owner, abuse or damage by others, or unusual phenomena or incidents beyond landscape installer's control which result from natural causes such as floods, lightning, storms, freezing rains, winds over 60 miles per hour, fires or vandalism.

B. Warranty Replacements:

1. During the warranty period, replace, at no additional cost to the Owner, plants that are damaged, dead, or, in the opinion of the Landscape Architect, are unhealthy, or have lost their natural shape due to dead branches, excessive pruning or improper maintenance. Rejected plant materials shall be removed from the site immediately after being rejected and legally disposed of off-site as they are identified.
2. Only one replacement of any plant is required after Substantial Completion, except for losses due to failure to comply with specified requirements.
3. Make replacements in accordance with the original specifications, plant list, and notes, no later than the next succeeding planting season. Fully restore areas damaged by replacement operations to their original and specified condition.
4. If, in the opinion of the Landscape Architect, it is advisable to extend the period of establishment for a second growing season, an inspection at the end of this extended period will be made to determine acceptability of the items involved. Improper planting and/or failure to conduct the year 1 maintenance in accordance with contract requirement shall be

the basis for extending the period of establishment for a second growing season. This extended period shall not be paid for separately.

C. Final Acceptance:
   1. Inspection will be made by the Owner, Contractor and Landscape Architect once all the terms of the warranty have been met and the site shall be in the condition stipulated under Article 3.4, Repair/Restoration. Final acceptance inspection of plantings or material planted during recognized planting seasons will be made one year after Substantial Completion or during the following September for fall plantings. Final acceptance will occur only after all punchlist items have been satisfactorily completed.

1.8 MAINTENANCE

A. Provide all equipment, materials, labor and services to maintain the landscape beginning immediately after each plant is installed and continuing until Final Acceptance at the end of the warranty period. Perform all work under the direct supervision of a technician trained to recognize and treat conditions affecting the established and growth of the plants.
   1. Inspect plants at least once per week and perform needed maintenance promptly.
   2. Irrigate all plants to maintain optimum moisture within the root zone; reoccurring overly dry or wet conditions according to species shall be grounds for rejection of plant material. If the irrigation system is inoperative, hand water from a source approved by the Landscape Architect. Do not apply water with a force that displaces mulch or causes soil erosion.
   3. Prune dead wood and broken limbs as identified, in accordance with Article 3.3.G, below. Do not shear evergreens. Maintain natural shape of trees and shrubs.
   4. Maintain stakes and guys taut and in the specified condition. Repair trees wraps if loose, torn or untied.
   5. Maintain all plant beds and tree saucers weed free. Edge shrub and perennial beds and tree rings at least monthly during the growing season, keeping all tree rings to a uniform diameter. Hook mulch monthly and add mulch as needed.
   6. Deadhead perennials as necessary during maintenance visits to extend blooming periods.
   7. Apply treatments as necessary to keep plants and planted areas free of insects, pests, and disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and herbicides. Treatments include utilizing physical and cultural controls.
   8. Apply pesticides and all other chemical products and biological control agents in accordance with the authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner at least 24 hours before each application is performed. No mixing or disposal of chemicals is allowed onsite.
   9. Apply antidesiccant to upright conifers December through February, at least once per month. Install burlap windscreens around spreading conifers and broadleaf evergreens but do not allow burlap to touch evergreen plants.
   10. Fertilization:
      a. Trees and shrubs: Fertilize once in the fall after the first hard freeze (usually October) but before the ground freezes; 1 pound of 4-1-2 (N-P-K) per 1,000 square feet of ground below the tree canopy or shrub bed.
      b. Perennials and vines: Fertilize twice, once in the early spring and again 8 weeks later with 1 pound per 100 square feet of 5-10-5.
   11. Remove dead and unacceptable plants as their condition becomes apparent.

B. At the end of the warranty period, but prior to Final Inspection, remove all guying, trunk wrap, watering saucers and re-mulch tree rings and beds as specified.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Plant Materials
1. All planting stock shall be nursery-grown, sound, healthy and vigorous, of uniform growth, typical of the species and variety, with the minimum quality conforming to American Standard for Nursery Stock, free of disease, insects, eggs, larvae, and defects such as knots, sunscald, injuries, weak crotch angles, abrasions or disfigurement. Unless noted otherwise, trees shall have straight single leaders and evergreens shall be unsheared. Branching on all plants shall be well-developed, dense, uniformly distributed and characteristic of the species.
   a. Plants indicated as specimen shall be exceptionally heavy, symmetrical, and superior in form, branching, and symmetry.
   b. Plants shall originate from same USDA Hardiness Zone as project site, or lower (colder).
2. Plant/ball sizing shall conform with the latest edition of ANSI Z60.1, American Standard for Nursery Stock, unless otherwise designated or modified in this section or on the plant list. Plants of a larger size may be used if acceptable to Landscape Architect and at no extra cost to Owner, with a proportionate increase in size of roots or balls.
   a. Height is indicated with a tolerance. The smaller dimension is the minimum acceptable; the larger dimension represents the maximum permissible except with approval of the Landscape Architect. The average dimension of all plants must, at least, equal the average of the tolerance figures shown on the drawings.
   b. Spread shall meet the minimum dimension specified in all directions and must be considered as pivoting on center of plant. Where tolerance is shown between two spread dimensions, the smaller dimension is the minimum acceptable. Spreads shall at least average on the median of the range indicated.
   c. Caliper is the trunk diameter taken at a specified distance above root collar as described in ANSI Z60.1.
   d. Branching height is the distance above ground where balanced branching occurs or where a dimension in trunk appears to form the head of the tree.
   e. Canes on shrubs shall arise at or just above the root crown. Multi-stem and clump form trees shall have branches that arise at the root crown or just above the root crown.
3. Root treatments on all plants shall conform to the requirements of ANSI Z60.1.
   a. Balled and burlapped ("B&B") plants shall have a firm, natural ball of earth securely wrapped with burlap, bound with cord and/or wire basket. Root flare shall be visible before planting.
   b. Containers shall be finished landscape grade material having their roots well established in the soil mass. Plants over-established in the container, as evidenced by pot-bound root ends, will not be accepted.
   c. Perennials and vines shall have a well-established root system reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Vines shall have min 3 main leaders.
4. Stressed or damaged plants or those not conforming to the specifications shall be subject to rejection by the owner at any time during the term of the contract.
5. Do not prune plants prior to delivery.

6. All plants shall have a label securely attached bearing legible designation of plant's common and scientific name, including genus and species, and cultivar or variety, if applicable.

B. Topsoil:
1. Refer to Section 32 91 20.
2. Topsoil for planting may originate onsite.

C. Mulch:
1. Organic mulch shall be well-composted, finely shredded processed hardwood bark, free from foreign material and fragments in excess of 2 inches in any dimension. Dyed red mulch will not be accepted.
2. Inorganic mulch (gravel), for maintenance strips and gravel mulched maintenance area at lift stations, shall be ¾" washed river gravel and conform to standard IDOT CA-11.
3. Inorganic mulch (gravel), for contrasting gravel mulch areas shall be 1 ½" washed river gravel and conform to standard IDOT CA-5.

D. Splash Pad:
1. Cobbles: Limestone 100%, 3-4" diameter, color: 85% in cream to tan range, 15% in brown or rust range.
2. Limestone Edging: Snapped, 4" x 4" profile.
3. Vinyl Edging: See Article 2.1L.

E. Staking and Guying Materials:
1. Stake deciduous trees less than 3 inch caliper; Stake upright evergreens less than 12 feet.
2. Tree support stakes shall be 2 inch x 2 inch hardwood posts 9 feet long.
3. Wire stays for tree stakes shall be pliable, No. 12 to 14 gauge galvanized wire.
4. Chafing guards shall be fiber-reinforced hose of not less than 1/2 inch inside diameter, color black.

F. Tree Wrap:
1. Tree wrap shall be 4-inch wide, two-ply, waterproofed crepe Kraft paper with plies cemented together with asphalt. Twine used to secure wrap shall be natural fiber two-ply jute; plastic twine is not acceptable.

G. Soil Amendments:
1. Peat shall be a product having at least 95% organic content consisting of sphagnum peat moss with a pH range of 3.0 – 4.0 and Von Post decomposition value of H1 – H3, or low-lime reed-sedge peat with a pH range of 4.0 to 5.0 and Von Post decomposition value of H4 – H6. Product shall be free of sticks, wood or other debris.
2. Compost shall be a mature/stabilized, humus-like material derived from the aerobic decomposition of yard clippings or other compostable materials. The compost shall have a dark brown or black color, be capable of supporting plant growth without ongoing addition of fertilizers or other soil amendments and shall not have an objectionable odor. The compost shall be free of plastic, glass, metal and other physical contaminants, as well as viable weed seeds and other plant parts capable of reproducing (except airborne weed species). The compost shall be visually inspected and approved at the composting site by the Landscape Architect for physical contaminants. The compost moisture content shall be such that no visible free water or dust is produced when handling it.
3. Sand shall be clean, coarse, ungraded, meeting the requirements of ASTM C33 for fine aggregates.

4. pH Adjusters:
   a. Lime shall be finely ground agricultural grade dolomitic limestone containing not less than 85% calcium and magnesium carbonates.
   b. Elemental sulfur shall be granular, biodegradable, horticultural grade material containing at least 90% sulfur, with a minimum of 99% passing through No. 6 (3.35-mm) sieve and a maximum of 10% passing through No. 40 (0.425-mm) sieve.

H. Fertilizer:
1. The fertilizer to be used to amend the soil before planting shall be granular fertilizer that conforms to applicable state and federal regulations, and contain nitrogen (of which 50% shall be organic), available phosphoric acid, and potash. Use formulation recommended by soil tests to amend site soil.
2. Fertilizer to be used during the year warranty maintenance period shall be a complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, not less than 30% of the nitrogen from a slow release source. Fifty percent of the nitrogen shall be derived from natural organic sources.
3. Fertilizer formulations shall be as outlined in Article 1.8A.10 of this Section.

I. Pesticides and Herbicides:
1. Pesticides and herbicides shall be registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for project conditions and application. Do not use restricted-use pesticides and herbicides unless authorized in writing by authorities having jurisdiction.

J. Antidesiccants:
1. Water-soluble emulsion specifically manufactured for agricultural use that will provide a protective film over plant surfaces and be permeable enough to permit transpiration. Use according to manufacturer's written instructions.

K. Soil Mixes:
1. Standard planting backfill shall be 1 part existing, well pulverized soil excavated from planting pit thoroughly blended with 1 part pre-approved topsoil.
2. Plant bed mix for shrubs and ground covers shall be 1 part existing, well-pulverized topsoil excavated from planting bed thoroughly blended with 1 part pre-approved topsoil and 1 part peat or compost.

L. Edging for Maintenance Strips:
1. Super-Edg, rigid vinyl and carbon black composition, as manufactured by Oly Ola Edgings, Inc., 1-800-EDGINGS, edgings@olyola.com.
2. Color: black, 6" height, .115-.130" thickness.
3. Stakes: Manufacturer's standard 14"
4. Connector clips: Manufacturer's standard H clips.

M. Horticultural Tree Watering Bags:
1. Shall be TreeGator Jr. as manufactured by TreeGator (866-873-3428), or approved equal. Provide one per tree. Remove at the end of the warranty period.
2. Watering Bags shall become the property of Laboratory.

N. Outcropping Stone:
1. Refer to Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. General:
   1. Prior to beginning work, examine and verify the acceptability of the project site and notify the Landscape Architect of unsatisfactory conditions. Do not proceed with the work until unsatisfactory conditions have been corrected or resolved.
   2. Where planting occurs in close proximity to other site improvements, provide adequate protection to all features prior to commencing work. Promptly repair any items damaged during planting operations to their original condition.
   3. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
   4. Suspend spoil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
   5. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

B. Utilities: Have all underground utilities located by servicing agencies. In the vicinity of utilities, hand-excavate to minimize possibility of damage.

C. On-site sources of water may not be available. Verify before beginning work.

D. Pesticides and Other Chemicals:
   1. Mixing or disposal of pesticides, herbicides, and other chemicals will not be permitted on site. Notify the Owner at least 24 hours prior to any application. Post all pesticide and herbicide applications.

E. Coordination with Other Work:
   1. The Contractor shall coordinate his/her work with other contractors or trades to determine the appropriate sequence of landscape installation with respect to other work on the site.
   2. Work installed out of construction sequence which is disturbed by the completion of work by other trades shall be repaired at no cost to the Owner.
   3. Maintain grade stakes set by others until removal is mutually agreed upon by all parties concerned.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.

B. Install erosion control measures, if necessary, to prevent erosion or displacement of soils and discharge of soil-bearing water run-off or airborne dust to adjacent properties and walkways.

C. Accurately lay out plant locations according to the drawings, using clearly visible painted stakes. Prior to installation, all locations must be approved by the Landscape Architect, who may field adjust locations at no additional cost to Laboratory. If layouts are not understood or if surface or subsurface obstructions are encountered that are not indicated, do not proceed with planting operations until alternative plant locations have been reviewed, selected, and approved in writing by the Landscape Architect.

D. Vegetation Removal:

1. Apply non-selective herbicide per the manufacturer's label to eradicate unwanted vegetation. Do not proceed with vegetation removal until the manufacturer's specified effective treatment period has expired.
2. Remove and legally dispose of all woody vegetation including roots within 12 inches of the surface.
3. Till existing herbaceous debris into soil or, if fine grading is required, strip and dispose of organic debris and root mat.

3.3 INSTALLATION

A. Excavation:
1. Remove rocks and other unclassified underground obstructions to at least 6 inches below the finished planting depth of the root ball. If underground utilities or other surface or subsurface obstructions are encountered, do not proceed with planting operations until alternate planting locations have been selected and approved by the Landscape Architect.
2. Size and configure planting pits in accordance with the planting details. If rotating augers or other mechanical diggers are used, scarify the side walls and bottom of the pit.
3. Excavate perennial and shrub beds to the depth shown on the drawings and replace with specified planting soil mixture, bringing the grades to a smooth and even surface which, when settled, will conform to established grades.
4. Remove excavated material that is not the specified planting soil to an area designated by the Owner.
5. Where poor soil percolation is probable, test drainage by filling planting pits with 12 inches of water. Record the drainage time for each pit and if, in the opinion of the Landscape Architect, the water does not adequately drain off within 24 hours, drill and shatter the substrate to a minimum depth of 3 feet below the bottom of the pit. Retest the drainage. If poor drainage persists, install drains as directed.

B. Maintenance Edge, Gravel Mulch, Splash Pads, Outcropping Stone:
1. Install per detail in Drawings.

C. Fertilizing:
1. Prior to or during planting, amend all backfill and bed mixes by incorporating fertilizer at rates specified by soil test reports.

D. Mycorrhizal Inoculum:
1. Incorporate 3 pounds per 100 square feet into the top 8 inches of soil.

E. Finish Grading:
1. Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet grade.
2. Before planting, obtain Landscape Architect’s acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

F. Planting:
1. Do not plant when the ground is frozen or saturated.
2. Balled and burlapped plants: Set the plant to the grade indicated on the details and face to give the best appearance or relationship to primary views. Cut away burlap, rope, wire or other wrapping materials from the top one-third of the ball, and remove from pit. If plastic wrap or other non-degradable materials are used in lieu of burlap, completely remove them

from the root ball before backfilling. Cleanly cut off broken or frayed roots. Backfill planting pit approximately two-thirds full, add water and allow planting mixture to settle. After the water has been absorbed, complete backfilling and tamp lightly to grade, and form a watering basin of the size indicated on Plans.

3. Container-grown stock: Remove containers and make at least five vertical cuts 1 inch deep around the root ball; thoroughly loosen the roots on the outside of the ball. Plant as specified above for balled and burlapped plants, and as modified herein. All container-grown stock shall be planted so that top of container soil is level with surrounding grade. Do not plant higher to account for mulch, as mulch should not cover plant crown.
4. If plants die or are rejected due to non-conformity to notes and/or specifications, that plant material must be removed from the site immediately and replaced before Substantial Completion.

G. Mulching:
1. Uniformly install mulch on all trees and shrub beds to depth shown on Plans within 48 hours of planting.
2. Keep mulch out of the crowns of shrubs and perennials, at least 3 inches from all tree trunks, and off sidewalks and roadways.

H. Pruning:
1. After planting, prune trees and shrubs to remove all dead, dying, broken, or crossed limbs. Do not prune to shape. Retain natural form of the plant type. Prune using standard professional horticultural and arboricultural practices. Remove trimmings from the site.
2. Employ workers experienced in this type of work.

I. Wrapping:
1. The trunks of deciduous trees shall be wrapped immediately after planting, but not before the condition of the trunks has been inspected and approved by the Landscape Architect. Trim the margins of any abrasions or cuts with a sharp, sterile knife prior to applying wrap.
2. Wrap trees beginning at the base and extending to the first branches in a spiral pattern with an overlap of half the width of the paper.
3. Secure the wrapping at the top, bottom and at 18 inch maximum intervals with twine.

J. Staking and Guying:
1. Install guying and staking as shown on the details immediately after planting.
2. Remove and dispose of stakes and guys at the end of the warranty period.

K. Edging:
1. Install shovel cut/spaded edge between all planting beds and lawn in the manner shown on the plans.
2. Install gravel maintenance edge between all building foundations and planting beds or lawn, and as noted in the Drawings and per manufacturer recommended directions.
3. Install between gravel maintenance edge and contrasting gravel mulch. Install per manufacturer recommended directions.

L. Mulch and stake plantings as detailed only after planting installation has been approved by the Landscape Architect.

3.4 REPAIR/RESTORATION

A. Remove excess and waste material daily. When planting has been completed, clear the site of all debris, stockpiles and materials.

B. Repair any damage to existing landscape, paving or other such features as a result of work related to this contract to its original condition.

C. Protect landscape work and materials from damage due to landscape operations, operations by other Contractors and trades, and trespassers. Maintain protection during installation and maintenance periods. Treat, repair or replace damaged landscape work as directed.

END OF SECTION

SECTION 33 11 00
WATER SERVICE

PART 1 - GENERAL

1.01 SUMMARY

A. Water service system as indicated and specified including fire protection and domestic water lines and appurtenances.

1.02 RELATED DOCUMENTS

A. Drawings

B. 31 20 00 – Earthwork

C. 31 23 33 – Trenching and Backfilling

1.03 SUBMITTALS

A. Manufacturers' literature, installation instructions, dimensions, materials, standards, certifications and guarantees.

B. Shop drawings for precast concrete manholes, piping, valves, tapping sleeves, fire hydrants, and other structures. Include frames, covers, and grates.

C. Inspection and test reports specified herein.

D. LEED Submittals:
   1. LEED Credit MR 4.1 and Credit MR 4.2: Submit product data for products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
      a. Include statement indicating costs for each product having recycled content.
   2. LEED Credit MR 5.1 and Credit MR 5.2: Submit product data for products that have extracted, harvested, or recovered, as well as manufactured within 500 miles of the Project site.
      a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the Project site.

PART 2 - PRODUCTS

2.01 DUCTILE IRON PIPE

A. Ductile iron pipe must conform to the requirements of AWWA C151 and with the additions or substitutions specified in this Section.

B. Pipe bells must be designed to provide a watertight joint without leakage and must be capable of withstanding pressures exceeding those that will rupture pipe of this class and thickness without requiring additional jointing material.

C. Electrical conductivity must be provided at each joint on all push-on and mechanical jointed pipe 16-Inches in diameter and smaller, to facilitate thawing of frozen pipe and building water services. Conductivity is to be accomplished by installing serrated silicon wedges as recommended or supplied by the pipe manufacture. The use of lead tip gaskets will not be allowed.

D. All pipes must be manufactured so that where a cut is made at any point along the barrel, the cut end will fit properly into a standard mechanical joint bell and be drip tight at hydrostatic test pressure.

E. Exterior of pipe must be coated with a petroleum asphaltic material in conformance with AWWA C110, Section 10-10. Interior of pipe must be cement lined in accordance with AWWA C104.

F. Pipe thickness and classes must conform to standards shown in Table A.

G. TABLE A PIPE THICKNESS AND CLASS

Pipe Size	Nominal Wall Thickness	Thickness Class
3-inch	0.34-inch	54
4-inch	0.38-inch	55
6-inch	0.40-inch	55
8-inch	0.45-inch	56
10-inch	0.47-inch	56
12-inch	0.49-inch	56

2.02 JOINTS

A. Lead joints are not to be used under any circumstances.

B. Pipe joints must be push-on type joints unless otherwise noted on the drawings or specified here. Push-on type joints must conform to AWWA C111.

C. Restrained joints when specified are to meet the following requirements:
   1. Mechanical joint pipe with mechanical joint restraint glands. Mechanical joints must conform to AWWA C110. Gaskets must conform to Section 2.04 of this specification.

2. Restrained joint pipe with manufactured weldment, field weldments or manufactured locking rings, locking segments and runner retainers and appurtenances conforming to AWWA C110. Acceptable products are Super-Lock Pipe manufactured by Clow Water Systems Company; FlexRing Pipe or Lok-Ring Pipe manufactured by American Ductile Iron Pipe; or TRFLEX manufactured by United States Pipe and Foundry Company.

D. Mechanical Joint Restraint Glands.
1. Provide restraint glands at all mechanical joints.
2. Restraint glands must be designed for use with the standardized mechanical joint bell pipe conforming to AWWA C110 and AWWA C153. Restraint is to be incorporated into the design of the gland. Acceptable products for this use are Mega Lugs manufactured by EBAA Iron Works; Uniflange manufactured by Ford Meter Box; or Star Grip manufactured by Star Pipe Products.
3. Restraint is to be accomplished by the use of multiple, wedge style restraints. Proper actuation of the wedges is to be ensured with torque limiting twist off nuts.
4. Glands 3-Inches through 16-Inches are to be pressure rated at 350-psi; glands 18-Inch through 48-Inch are to be rated at 250 psi.
5. The gland body and restraint components are to be made from ductile iron conforming to ASTM A536, 65-45-12. Ductile iron wedges are to be heat-treated within a range of 370 to 470 BHN.
6. The joint is to be capable of full deflection during assembly and joint deflection after assembly
7. Provide glands with minimum weights and number of wedges as shown in Table B.
8. Retainer glands are not acceptable.

E. TABLE B – Minimum Weight and Number of Wedges Per Restrained Joint

Pipe Size	Number of Wedges	Minimum Weight
3-inch	2	6.0 lbs
4-inch	2	7.0 lbs
6-inch	3	11.0 lbs
8-inch	4	14.5 lbs
10-inch	6	23.0 lbs
12-inch	8	28.5 lbs

F. Flanged joints must conform to the following:
1. Flanged joints must conform to AWWA C115. Flanges must be the long hub type, screwed on the threaded end of the pipe in the shop. There must be no leakage through the pipe threads. The flanges must be designed to prevent corrosion of the threads from the outside.

2. Flanges must be drilled according to the requirements of ANSI/ASME B16.1, Class 125 unless special drilling is called for on the Drawings or specified. Bolt holes must be equally spaced, drilled smooth and true. When stud bolts are used flanges must be drilled and tapped to accommodate the studs.
3. The face of the screwed-on flange and plain-end of the pipe must be accurately refaced together, at right angles to the pipe axis. After facing and drilling, the face of the screwed-on flange must immediately be covered with an appropriate rust-preventive coating.
4. Flanged joints must be secured with either bolts and nuts, or stud bolts with a nuts. Bolts, stud bolts, and nuts must meet the requirements of ASTM A307, Grade B. Bolts and stud bolts must conform to ANSI/ASME B18.2.1. Nuts must conform to ANSI/ASME B18.2.2. All bolts, stud bolts, and nuts must be primed with bitumastic paint after the bolts and nuts have been installed and tightened.
5. Gaskets must conform to Section 2.04 of this specification.

2.03 FITTINGS

A. Fittings to be furnished and installed as specified or shown on the Drawings must be mechanical joint, ductile iron in accordance with AWWA C110. Laying length of mechanical joint castings must be as shown in AWWA C110. Wall thickness and allowable variation in the thickness of mechanical joint castings must conform to AWWA C110 and have a 250-psi pressure rating.

B. Compact fittings may not be used.

C. Plain ends of mechanical joint fittings must be beveled and gauged to properly seat in push-on joint bells.

D. The fittings must be smooth and free from defects of every nature that would make them unfit for the use that they were intended. Plugging of fittings is not allowed. Repairing of defects by welding will be allowed if such repairs will not adversely affect the serviceability of the fittings or their ability to meet the strength requirements of the referenced AWWA standards.

E. All castings must be coated inside and outside with a petroleum asphaltic material in conformance with Section 4.3 of AWWA C110. A cement-mortar lining is not required.

F. Flanged fittings must conform to AWWA C110, and have a 150-pound per square inch pressure rating.

G. Tapping valves shall conform to AWWA C500, MSS SP 60 and MSS SP 111 and/or SP 113.

H. Tapping sleeves shall be stainless steel and conform to MSS SP 60,SP 111 and SP 113.

2.04 GASKETS

A. All gaskets for pipe, fittings and appurtenances must be vulcanized natural or vulcanized synthetic rubber, non-porous, free of foreign materials and visible defects. Recycled rubber may not be used.

B. When soil conditions do not permit the use of natural or synthetic rubber gaskets, all gaskets for pipe, fittings and appurtenances must be Nitrile (acrylonitrile butadiene), nonporous, free of foreign materials and visible defects.

C. Gaskets for flanged joints must be of the ring type, 1/16-Inch thick, and meet the requirements of ANSI Standard B16.21. Acceptable manufacturers include the Crane Company; Garlock Packing Company; or U.S. Rubber Company.

D. Gaskets must be stored in a cool place and protected from light, heat, oil, or grease until installed. Any gasket showing signs of cracking, weathering, abrasion or other deterioration will be rejected.

2.05 POLYETHYLENE ENCASEMENT

A. Polyethylene encasement material must be either 8-mil, low density or 4-mil, cross-laminated, high-density polyethylene tubing in accordance with AWWA C105.

1. Provide polyethylene water main encasement at all water mains.

2.06 FIRE HYDRANTS

A. See drawings for additional fire hydrant details and specified locations.

B. Materials from which the various parts of the hydrants are constructed must be of the kind designated on the details. Each kind of material used must meet the requirements as to physical and chemical properties hereafter specified. Test bars required to established quality grade or strength under the ASTM standards must be made and machined by the manufacturer as part of the work.

C. 3/4-Inch x 2-3/4-Inch unfinished hex head machine bolts and 3/4-Inch American Standard regular hot press hex nuts must conform to Federal Specification FF-B-575C, Class B Steel, Class 1 fit or, hex head bolts and hex nuts must conform to ASTM A307 Grade A. All nuts and bolts to be hot dipped galvanized conforming to ASTM A153 or must be coated by the rust proof electrozinc process ASTM B633, Type G.S., or SS Type 18-8SS, ANSI Type 302, 303, or 304.

D. Iron castings must conform to ASTM A126 Class B. The thickness of metal castings, whose standard thickness is less than 0.8-Inch, must not be more than 0.08-Inch less than the standard thickness. The deficiency in thickness of castings, whose standard thickness is 0.8-Inch or more, must not exceed 10% of the standard thickness. The above allowable deficiencies in thickness must not extend over more than one-half of the area of any casting. The diameter of the castings must not vary from the standard dimensions by more than 08-Inch.

E. All bronze castings, with the exception of the stem nut, stem screw, and valve seats must conform to ASTM B62 for Leaded Red Brass Copper Alloy UNS No. C83600. The valve seat must conform to ASTM B584 for Leaded Manganese Bronze, Copper Alloy UNS No. C86700. The stem nut and stem screw must conform to ASTM B584 for Silicon Brass, Copper Alloy UNS No. C87600 with the following mechanical properties:

1. Minimum Tensile Strength - 45,000-psi
2. Minimum Yield Strength - 25,000 psi
3. Minimum Elongation - 16% of length
4. Brinell Hardness – 110

F. The stem nut and stem screw must be stamped SI for identification purposes.

G. Wrench nuts made of ductile iron must be marked “D.I.” on the flange portion opposite the arrow indicating the direction of turn to open.

H. Ductile iron castings must comply with compositions and physical properties in accordance with ASTM A536 Grade 65-45-12.

I. Full face gasket of suitable material, 1/16-inch thick, 8 ½-inches X 13 ½-inches, with eight (8) 7/8-inch diameter holes on an 11 3/4-inch bolt circle must be provided for the hydrant flange gaskets.

J. Steel hydrant chain must comply with Federal Specification RR-C-271D (1), Type II, Class 2, with an approximate weight of 25-pounds per 100 feet, and have a hot galvanized coating. This chain, approximately 26-Inches long, must be connected to hydrant cap hooks and fastened at its center to the hydrant by means of the ½-Inch X 1-Inch cap screw with chain angle and "S" hook of ½-Inch mild steel stock "S" hook and cap hooks which engage the chain, must be securely welded in the closed position or fastened in a suitable manner to hold the hooks securely in a closed position.

K. Where the Plans call for finish and drilling, all such work must accurately comply with the dimensions shown, so that all parts are interchangeable from one hydrant to another. It will be the manufacturer’s responsibility to provide the patterns and gauges necessary to perform the work specified.

L. Where machining tolerances are not indicated on the drawings, the following must be used where applicable:
1. If dimension is in decimals, tolerance is ± 0.005-Inch.
2. If dimension is in inches, tolerance is ± 1/64-Inch.

M. Appropriate lubricant must be applied to threads on hydrant bottom, ½-Inch X 1-Inch cap screw and valve seat before assembly.

N. Operating stem must be of cold rolled steel, ASTM A108 Grade 1018. Stem must be coated, excluding bottom 3-7/8-Inch of the section below shoulder including threads, with a bituminous coating.

O. Rubber Gaskets must comply with ASTM D2000; Type SC-715B, as follows:
1. Shore A Durometer Hardness - 70 + 5 ASTM D2240.
2. Tensile Strength - 1500-psi minimum ASTM D412.
3. Compression Set - 35% maximum ASTM D395.

P. Paint
1. All ferrous metal parts of the hydrant, inside and outside, must be thoroughly cleaned before coating. Coatings used on interior surfaces of the hydrant that are

in contact with potable water must be suitable for contact with drinking water. Prepare hydrant surfaces and apply paint in accordance with paint manufacturer's recommendations. Do not paint exposed hydrant nozzle threads or other useable threads.

2. Primer must be oxide primer; acceptable products are W. C. Richards Metal primer #WRFA-13-127; or Benjamin Moore Universal Metal Primer # M07.
3. Top coat must be alkyd high-gloss enamel; acceptable produces are Benjamin Moore Impervo or Sherwin Williams Industrial Enamel. Color to be per Laboratory standards (yellow with green top flange).
4. Shop Coating of Fire Hydrants.
   a. Exterior ferrous surfaces of the hydrant must be painted with a coat of primer to two feet below the top flange.
   b. Exterior ferrous surfaces of the hydrant must be given a topcoat of alkyd high-gloss enamel to two feet below the top flange.
   c. All exterior ferrous surfaces below the ground line not coated with primer and topcoat must be shop coated with two (2) coats of asphaltic coating, each a minimum of 1 mil thick. The first coat must be allowed to dry thoroughly before applying the second coat.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All ductile iron pipe, fittings, and appurtenances must be installed in accordance with the manufacturer's recommendations and requirements.

B. All pipe, fittings, and accessories must be delivered, unloaded, strung, and laid as specified here.

C. The water mains must be laid with depths of cover as indicated under Article 3.11 of this specification, unless otherwise shown on the drawings. The pipes must be laid true to line and grade.

D. Fittings as specified must be used where shown on the drawings and where grade or alignment changes require offsets greater than those recommended by the pipe manufacturer.

3.02 TRANSPORTATION, DELIVERY AND STORAGE

A. Every precaution must be taken to prevent damage to the pipe during transportation and delivery. Pipe ends must be sealed with caps or by another suitable method upon taking delivery from the supplier. Extreme care must be taken in loading and unloading the pipe and fittings. Such work must be done slowly with skids or suitable power equipment and the pipe must be under complete control at all times. Under no conditions may the pipe be dropped, bumped, dragged, pushed, or moved in any way that will cause damage to the pipe. When handling the pipe with a crane, a suitable pipe hook or rope sling around the pipe must be used. Under no condition may the sling be allowed to pass through the pipe unless adequate measures are taken to prevent damage to the pipe ends and lining.

B. If in the process of transportation, handling, or installation, any pipe or fitting is damaged, such pipe or fitting must be replaced by the Contractor and be considered incidental to the construction and no additional payment will be allowed.

C. The Contractor must store pipe in a manner that will prevent damage. Pipe must be placed on wooden timbers or another suitable support on level ground. The Contractor must prevent the pipe from rolling.

3.03 PREPARATION FOR LAYING PIPE

A. Materials, coatings, and linings must be as specified herein or as shown on drawings. Water mains and services must be installed where shown on the drawings. Installation must be in accordance with standards as recommended by the pipe manufacturer, and as specified herein.

B. Proper and suitable tools and appliances for the safe and convenient cutting, handling, and laying of the pipe and fittings must be used.

C. Before lying, all pipe and fittings must be thoroughly examined for defects and no piece may be installed which is known to be defective. If defects are discovered after pipe or fittings have been installed, the Contractor must remove the defective pipe and/or fitting and replace it with a sound one at his expense.

D. The pipe and fittings must be thoroughly cleaned before they are laid and must be kept clean until they are accepted in the finished work. Care must be exercised to avoid leaving bits of wood, dirt, rock and other foreign particles in the pipe. If any such materials are discovered before the final acceptance of the work, they must be removed and the pipe and fittings replaced, if necessary. All pipes must be kept absolutely clean during construction and must be stopped off with night plugs at the end of each day's work. Exposed ends of uncompleted lines and existing water mains and services cut and not abandoned must be capped or otherwise temporarily sealed at all times when pipe laying is not in progress.

E. When cutting ductile iron pipe, it must be neatly cut perpendicular to the longitudinal axis of the pipe without damaging the pipes lining or coating or jointing surface area.

3.04 LAYING WATER SERVICE PIPE

A. The Contractor shall do all excavation of whatever unclassified material is encountered to the depths established by the Engineer. Trench depths, not established, shall be figured to allow a minimum cover over the top of the pipe as dictated herein.

1. In open cut excavation, the Contractor shall keep the trench width at the top of the pipe not wider than established, unless the angle of repose of the soil is unsuitable.

B. All pipelines must be laid in trench excavations on bedding or other foundations, as shown on the drawings and as specified herein. The pipe must be properly secured against movement and pipe joints must be made in the excavation as required. Pipes must have solid bearing throughout their entire length.

C. At locations where pipe thrust is anticipated to occur, pipe and fittings must be anchored or restrained as shown on the drawings.

D. Pipe lying will be permitted only in dry trenches having a stable bottom. The contractor shall remove, by pumping or other means, any water accumulated in the excavation and keep the trench dry during the pipe laying period. The contractor shall provide adequate pumps, well points, or other dewatering method at no extra cost to the Laboratory. If the trench bottom is unsuitable for the pipes foundation, the kind of stabilization to be utilized will be ordered in writing.

E. The Contractor must take such required precautions to prevent flotation of the new pipeline.

3.05 HORIZONTAL SEPARATION - WATER MAINS AND SEWERS

A. The work under this section shall be in accordance with IEPA requirements.

B. Water mains shall be located at least ten feet horizontally from any existing or proposed drain, storm sewer, sanitary sewer, combined sewer or sewer service connection.

C. Water mains may be located closer than ten feet to a sewer line when:
1. Local conditions prevent a lateral separation of ten feet; and
2. The water main invert is at least 18 inches above the crown of the sewer; and
3. The water main is either in a separate trench or in the same trench on an undisturbed earth shelf located to one side of the sewer.

D. When it is impossible to meet (B) or (C) above, both the water main and drain or sewer shall be constructed of slip-on mechanical joint cast or ductile iron pipe. The drain or sewer shall be pressure tested to the maximum expected surcharge head before backfilling.

3.06 VERTICAL SEPARATION - WATER MAINS AND SEWERS

A. A water main shall be separated from a sewer so that its invert is a minimum of 18 inches above the crown of the drain or sewer whenever water mains cross storm sewers, vertical separation shall be maintained for that portion of the water main located within ten feet horizontally of any sewer or drain crossed. A length of water main pipe shall be centered over the sewer to be crossed with joints equidistant from the sewer or drain.

B. Both the water main and sewer shall be constructed of slip-on or mechanical joint cast or ductile iron pipe, prestressed concrete pipe, when:
1. It is impossible to obtain the proper vertical separation as described in (A) above; or
2. The water main passes under a sewer or drain.

C. A vertical separation of 18 inches between the invert of the sewer or drain and the crown of the water main shall be maintained where a water main crosses under a sewer. Support the sewer or drain lines to prevent settling and creaking the water main, as shown on the plans or as approved by the Engineer.

D. Construction shall extend on each side of the crossing until the perpendicular distance from the water main to the sewer or drain line is at least ten feet.

3.07 ASSEMBLY OF FLANGED JOINTS

A. Flanged joints must be made with bolts or bolt studs with nuts as specified in Section 2.2 of this specification.

B. Tighten flange bolts as recommended by the gasket manufacturer to ensure an evenly compressed gasket and leak tight joint.

C. After the bolts and nuts have been properly installed, tightened, and cleaned, prime them with bitumastic paint.

3.08 ASSEMBLY OF MECHANICAL JOINTS

A. Thoroughly brush the surfaces with which the rubber gasket comes in contact with a wire brush just prior to assembly of the joint. Brush lubricant over the gasket and the plain end just prior to installation. In making up mechanical joints, the spigot must be centered in the bell.

B. The gasket and gland must be placed in position, the bolts inserted, and the nuts tightened finger tight. The nuts must be tightened by means of a torque wrench in such a manner that the gland must be brought up evenly into the joint.

C. Joints are to be made up to allow electrical continuity from one pipe to another by installing wedges as specified in Article 2.02, paragraph D of this specification and are to be installed in the following manner:

1. Use two (2) wedges per joint for 3-Inch to 12-Inch diameter pipes. Wedges must be placed on opposite sides of the joint at an equal distance apart (9 and 3 o'clock positions) around the joint.
2. Use four (4) wedges per joint for 16-inch to 24-inch diameter pipes. Wedges must be installed side by side in pairs placed on opposite sides of the joint at an equal distance apart (9 and 3 o'clock positions) around the joint.
3. Use six (6) wedges per joint for pipes larger than 24-inches in diameter only if building services are directly connected to the main. Wedges must be installed side by side in pairs 120 degrees apart at the 12, 4, and 8 o'clock positions around the joint.
4. The following range of bolt torques must be applied as specified in Table C. If sealing is not obtained at the maximum torque requirements listed in Table C, the joint must be disassembled, thoroughly cleaned, and reassembled.

3.09 TABLE C – Bolt Torque Requirements

Bolt Size	Torque Range
5/8 - inch	45-60 ft-lbs

3/4 - inch	75-90 ft-lbs
1 - inch	85-100 ft-lbs
1 ¼ inches	105-120 ft-lbs

3.10 ASSEMBLY OF PUSH-ON RUBBER GASKET JOINTS

A. Thoroughly brush the gasket seat in the bell with a wire brush and wipe the gasket and gasket seat with a cloth. Place the gasket in the socket with the large round end entering first so that the groove fits over the bead in the seat. Apply a thin film of NSF 61 approved joint lubricant to the inside surface of the gasket that will come into contact with the entering pipe.

B. Thoroughly brush the plain end of the pipe with a wire brush and placed it in alignment with the bell of the pipe to which it is to be joined. Make up the joint by exerting sufficient force on the entering pipe so that its plain end is moved past the gasket until it makes contact with the base of the socket.

C. Joints are to be made up to provide electrical continuity from one pipe to another by installing wedges as specified in Article 2.02, paragraph D of this specification and are to be installed in the following manner: 1. Use two (2) wedges per joint for 3-Inch to 12-Inch diameter pipes. Wedges must be placed on opposite sides of the joint at an equal distance apart (9 and 3 o'clock positions) around the joint. 2. Use four (4) wedges per joint for 16-Inch to 24-Inch diameter pipes. Wedges must be installed side by side in pairs placed on opposite sides of the joint at an equal distance apart (9 and 3 o'clock positions) around the joint. 3. Use six (6) wedges per joint for pipes larger than 24-Inches in diameter only if building services are directly connected to the main. Wedges must be installed side by side in pairs 120 degrees apart at the 12, 4, and 8 o'clock positions around the joint.

D. Assemble restrained joint pipe in accordance with manufacturer's instructions.

3.11 DEPTH OF PIPE COVER

A. Unless otherwise shown on the Plans, all water mains and services must be installed so a minimum pipe cover is achieved as shown in Table D.

B. TABLE D – Minimum Depth of Cover for Water Mains

Size of Pipe	Depth of Cover
3/4 to 3-inches	5-ft 6-inches+ 3-inches
4-inch	5-ft 6-inches + 3-inches
6-inch	5-ft 6-inches + 3-inches

8-inch	5-ft 3-inches + 3-inches
10-inch	5-ft + 2-inches
12-inch	5-ft + 2-inches

3.12 CONSTRUCTION PROCEDURES

A. BEDDING: See drawings and specification Trenching and Backfilling.

1. As established by Contractor, or where necessary because of soil conditions, concrete cradles or concrete encasement shall be built. The pad section of a cradle or encasement shall be built at least twelve (12) hours before pipe laying. A sufficient number of No. 9 annealed iron pipes shall be embedded in the pad and subsequently tied around the pipe to prevent the pipe from moving off line and/or grade.

B. INSTALLATION OF PIPE: Before lowering the pipe into the trench and while suspended, each pipe shall be inspected by the Contractor for defects. Defective, damaged or unsound pipe shall be immediately removed from the site. The interior of each pipe shall be inspected for cleanness and cleared of all dirt and foreign matter before being lowered into the trench.

1. Unless otherwise directed, pipe shall be laid with bell ends facing in the direction of laying. After a length of pipe is placed in the trench, the spigot shall be centered in the bell of the preceding pipe, the pipe shoved into position and brought to true alignment and there secured with sand tamped under and on each side of the pipe, excepting at bell holes. No earth or other foreign matter shall be allowed to enter into the joint space.
2. The bells, spigots and rubber gaskets shall then be thoroughly washed in soapy water so that no particles of sand of grit can damage the gasket. Slip-on joints shall be constructed in strict accordance with the manufacturer's recommendations.

C. BACKFILLING:

1. Backfill of auxiliary valves and line valves shall be carefully tamped to insure proper alignment. Contractor shall properly align and set to grade all valve boxes after completion of curb and gutter construction.
2. PIPE ZONE: See drawings and section Trenching and Backfilling. Bedding shall be carefully placed and thoroughly tamped and compacted around the pipe with hand tools up to the spring line of the pipe.
3. GRANULAR TRENCH BACKFILL: All trenches and the excavation around fire hydrants, valves and other appurtenances which occur within the limits of existing or proposed pavements, sidewalks and curb and gutters, or where the edge of the trench shall be within two feet (2') of said improvements shall be backfilled with compacted granular backfill.
4. GUARANTEE: The contractor shall guarantee all work for a period of one year after acceptance by the Laboratory. Any trenches improperly backfilled or where settlement occurs shall be reopened and properly compacted. The cost of any corrections and/or repair of any damages to other facilities shall be the responsibility of the Contractor.

3.13 TESTING, DISINFECTION, AND FLUSHING OF DOMESTIC WATER LINES

A. Test in accordance with AWWA C600 and C605, IEPA requirements, and the paragraph below.

1. Testing of the newly laid piping or any valved section of piping shall be accomplished after the lines are laid, the joints and accessories installed, and the trench partially backfilled, leaving the joint exposed for examination. The piping shall be subjected for a minimum of two hours to a pressure of one and one-half times the working pressure, but in no case less than l00 psi (689 kPa). Examine all exposed pipe, joints, fittings and accessories during the test period. Replace or repair defective portions of the system, and repeat tests until results are satisfactory. Allowable leakage shall be as specified in AWWA C-600, Table 3.

B. Disinfect water main per AWWA Standard C651 and IEPA requirements.

C. Flushing operations for domestic water lines shall discharge to an open landscape area. Discharge into storm and sanitary sewer will not be permitted.

3.14 WATER SERVICE TAPPING

1. Pressure tap existing water main per IEPA requirements. Provide stainless steel saddle at tap locations on existing water main.

3.15 FIRE HYDRANTS

A. Securely connect fire hydrant to the water main using mechanical joint thrust restraint glands or other restrained joint fittings as shown on the drawings.

B. Pressure test the fire hydrant installation with full line pressure to the fire hydrant without blocking behind the fire hydrant.

C. Hydrant leads must be 8-Inches in diameter, or as otherwise specified or shown on the Plans. Spool pieces are not allowed for the vertical adjustment of hydrants. If a vertical adjustment is required due to the depth of the water main, an offset must be utilized prior to installing the hydrant.

END OF SECTION 33 11 00

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SECTION 33 31 00
SEWERAGE AND DRAINAGE

PART 1 - GENERAL

1.01 SUMMARY:

A. The work covered in this section consists of furnishing all labor, materials, tools, and equipment required to install storm, sanitary, and lab sewer waste systems as established by the Contractor in continuity to the plans and specification for the complete system. The work shall include but is not limited to excavation for sewer pipes and structures, sewer pipe and structure installation, backfilling trenches, and testing of the complete systems as required.

1.02 RELATED SECTIONS

A. Drawings

B. 31 20 00 – Earthwork

C. 21 23 33 – Trenching and Backfilling

1.03 Definitions:

A. Lab Waste Sewerage Piping: System of sewer pipe, fittings, and appurtenances of lab waste discharge.

B. Sanitary Sewerage Piping: System of sewer pipe, fittings, and appurtenances of sanitary sewage.

C. Storm Sewerage Piping: System of sewer pipe, fittings, and appurtenances of storm sewer.

1.04 SUBMITTALS

A. Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Shop drawings for precast concrete drainage and sewerage structures and piping. Include frames, covers, and grates, and pipe fittings.

C. Submit test results and findings in accordance with section 3.10 “Field Quality Control”.

1.05 QUALITY ASSURANCE

A. Environmental Agency Compliance: Comply with regulations pertaining to sanitary sewerage and storm drainage systems.

B. Utility Compliance: Comply with regulations pertaining to sanitary sewerage and lab waste systems. Include standards of water and other utilities where appropriate.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect pipe, pipe fittings, and seals from dirt and damage.

B. Handle precast concrete manholes and other structures according to manufacturer's rigging instructions.

1.07 PROJECT CONDITIONS

A. Site Information: Perform site survey and verify existing utility locations prior to construction.

B. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Laboratory except when permitted under the following conditions and then only after arranging to provide acceptable temporary utility services.
   1. Notify the Laboratory not less than 72 hours in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without receiving the Laboratory’s written permission.

1.08 SEQUENCING AND SCHEDULING

A. Coordinate with interior building systems.

B. Coordinate with other utility work.

PART 2 - PRODUCTS

2.01 PIPE MATERIAL

A. Sanitary Sewer HDPE Pipe and Fittings
   1. PVC pipe and fittings: SDR 26 meeting ASTM D 2241. Pipe joints to have flexible elastomeric seals per ASTM D3139, with ASTM F477 gaskets.

B. Lab Waste Sewer Polypropylene Pipe (PP)

1. Polypropylene pipe and fittings: ASTM D4101, ASTM D 638, and ASTM F2389 for SDR 11. Pipe joints shall have heat fusion joints per ASTM D 2657.

C. Ductile-Iron Pipe and Fittings - Storm Sewer, Push-on-Joint Piping:
1. Pipe: AWWA C151.
2. Standard Fittings: AWWA C110, ductile or gray iron.
3. Compact Fittings: AWWA C153.
4. Gaskets: AWWA C111, rubber, of shape matching pipe and fittings.
5. Interior Coating: AWWA C104.

D. REINFORCED CONCRETE PIPE, STORM SEWER
1. Reinforced Concrete Pipe, minimum class III unless otherwise indicated on the plans. Conform to ASTM C-76 with joints conforming to ASTM Specification C-443.
2. Flared End Section per IDOT requirements and as indicated on plans.

E. PVC STORM SEWER
1. PVC pipe and fittings: SDR 26 meeting ASTM D 2241. Pipe joints to have flexible elastomeric seals per ASTM D3139, with ASTM F477 gaskets.
2. Perforated pipe: ASTM D 3034; PVC-SDR-26. Provide four rows of perforations meeting AASHTO M278 specifications. Joints ASTM D 2855 or ASTM D 3212.

2.02 CLEANOUTS

A. Ductile Iron Cleanouts:
1. Manufacturers: Subject to compliance with requirements.
2. Basis-of-Design Product: Subject to compliance with requirement.
3. Description: Ductile iron body with threaded plug. Include ductile iron sewer pipe fitting and riser to cleanout of same material as sewer piping. Include heavy duty cleanout cap at areas of vehicular pavement.

2.03 MANHOLES

A. Precast Concrete Manholes: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for rubber gasket joints.
1. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent floatation.
2. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having a separate base slab or base section with integral floor.
3. Riser Sections: 4-inch minimum thickness, 48-inch diameter, and lengths to provide depth indicated.
4. Top Section: Eccentric cone type, unless concentric cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
5. Gaskets: ASTM C 443 (ASTM C 443M), rubber.
6. Grade Rings: Include 2 or 3 reinforced-concrete rings, of 6- to 9-inch total thickness, that match a 24-inch- diameter frame and cover.

7. Steps: ASTM C 478 (ASTM C 478M) individual steps or ladder. Omit steps for manholes less than 60 inches deep.
8. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.

B. Manhole Frames and Covers: ASTM A-48, Class 35B, cast gray iron. All manhole lids to have bolt lock device. Include indented top design with raised, flush lettering cast into cover per script as indicated on drawings.

2.04 CATCH BASINS

A. Precast Concrete Catch Basins: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for rubber gasket joints.
1. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (100-mm) minimum thickness for walls and base riser section, and having a separate base slab or base section with integral floor.
2. Riser Sections: 4-inch (100-mm) minimum thickness; 48-inch (1220-mm) diameter, and lengths to provide depth indicated.
3. Top Section: Eccentric cone type, unless concentric cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
4. Gaskets: ASTM C 443 (ASTM C 443M), rubber.
5. Grade Rings: Include 2 or 3 reinforced-concrete rings, of 6- to 9-inch (152- to 229-mm) total thickness, that match a 24-inch- (610-mm-) diameter frame and grate.
6. Steps: ASTM C 478 (ASTM C 478M) individual steps or ladder. Omit steps for catch basins less than 60 inches (1500 mm) deep.
7. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.

B. Frames and Grates:
1. Catch Basin Frames and Covers: ASTM A-48, Class 35B, cast gray iron. Include indented top design with lettering cast into cover: STORM SEWER

C. TRENCH DRAIN
1. Trench drain to be ACO S300K 12” (W) heavy duty trench drain or approved equal.
2. Grate to be heavy duty, ADA compliant locking ductile iron.
   a. Load Class F lid.
   b. Rated for Heavy Duty Vehicular Loading.

2.05 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350R, and the following:
1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Structures: Portland-cement design mix, 4000 psi (27.6 MPa) minimum, with 0.45 maximum water-cement ratio.
   1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
   2. Reinforcement Bars: ASTM A 615, Grade 60 (ASTM A 615M, Grade 400), deformed steel.

2.06 PROTECTIVE COATINGS

A. General: Include factory- or field-applied protective coatings to structures and appurtenances according to the following:

B. Coating: 1- or 2-coat, coal-tar epoxy, 15-mil (0.381-mm) minimum thickness, except where otherwise indicated.
   1. Manholes: On exterior surfaces.
   2. Catch Basins: On exterior surfaces.

PART 3 - EXECUTION

3.01 EARTHWORK

1. Excavating, trenching, and backfilling are specified in Earthwork and Trenching and Backfilling Sections.

3.02 IDENTIFICATION

A. Install green warning tapes 6” over piping, centered, and at outside edges of underground structures.
   1. Use detectable warning tape over nonferrous piping and over edges of underground structures as specified in 31 23 33.

3.03 SEWERAGE PIPING APPLICATIONS

A. General: Include watertight joints.

B. Provide pipe material as shown on drawings and per Part 2-Products.

3.04 INSTALLATION, GENERAL

A. General Locations and Arrangements: Drawings (plans and details) indicate the general location and arrangement of underground sewerage and drainage systems piping. Location and arrangement of piping layout take into account many design considerations. Install piping as indicated, to extent practical.

B. Install piping beginning at low point of sewer systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's recommendations for use of lubricants, cements, and other installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.

C. Install gravity-flow-systems piping at constant slope between points and elevations indicated. Install straight piping runs at constant slope, not less than that specified, where slope is not indicated.

D. Extend piping and connect at sizes and in locations indicated. Terminate piping as indicated.

E. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

F. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

G. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

H. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

I. Install gravity-flow, nonpressure, piping according to the following:
   1. Install ductile-iron, gravity sewer piping according to ASTM A 746.
   2. Install PVC gravity sewer piping according to ASTM D 2321 and ASTM F 1668.
   3. Install polypropylene gravity sewer in accordance with ASTM D2774
   4. Install RCP piping in accordance with ASTM C1479.

J. Install pressure piping according to the following:
   1. Install piping with restrained joints at tee fittings and bends and at horizontal and vertical changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
   2. Install piping to elevation indicated on drawings.
   3. Install HPDE pressure piping according to ASTM D3035/ASTM F2160.
   4. Install Polypropylene pressure piping according to ASTM D 2774

K. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.05 PIPE JOINT CONSTRUCTION AND INSTALLATION

A. Join gravity-flow, nonpressure, drainage piping according to the following:

1. Join ductile-iron, gravity sewer piping according to AWWA C600 for push-on joints.
2. Join PVC gravity sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasket joints.
3. Join dissimilar pipe materials with nonpressure-type, flexible couplings.
4. Join RCP pipe in accordance with ASTM C443.

B. Join pressure piping according to the following:
1. Join PVC pressure piping according to ASTM 3350 and AWWA C906.
2. Join Polypropylene piping according to ASTM D2657. Comply with manufacturer's instructions concerning equipment, temperature, melt, and joining time.
3. Join dissimilar pipe materials with pressure-type couplings.

3.06 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts, and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
3. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.

B. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.07 MANHOLE INSTALLATION

A. General: Install manholes, complete with accessories, as indicated.

B. Set tops of frames and covers flush with finished surface where manholes occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere, except where otherwise indicated.

C. Place precast concrete manhole sections as indicated, and install according to ASTM C 891.

D. Provide rubber joint gasket complying with ASTM C 443 (ASTM C 443M), at joints of sections.

E. Apply bituminous mastic coating at joints of sections.

F. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.08 CATCH BASIN INSTALLATION

A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

3.09 CONNECTIONS

A. Make connections to existing piping and underground structures so finished work conforms as nearly as practical to requirements specified for new work.

B. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch (150-mm) overlap, with not less than 6 inches (150 mm) of 3000-psi (20.7-MPa), 28-day, compressive-strength concrete.

C. Make branch connections from side into existing piping, sizes 4 to 20 inches (100 to 500 mm) by removing a section of existing pipe and installing a wye fitting into existing piping. Encase entire wye with not less than 6 inches (150 mm) of 3000-psi (20.7-MPa), 28-day, compressive-strength concrete.
   1. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi (20.7 MPa), unless otherwise indicated.
   2. Use epoxy bonding compound as an interface between new and existing concrete and piping materials.

D. Protect existing piping and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

E. Provide pressure rated transition couplings for joining existing and new pipe.

3.10 FIELD QUALITY CONTROL

A. Clear interior of piping and structures of dirt and superfluous material as the work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.
   1. In large, accessible piping, brushes and brooms may be used for cleaning.
   2. Place plug in end of incomplete piping at end of day and whenever work stops.
   3. Flush piping between manholes and other structures, if required by authorities having jurisdiction, to remove collected debris.

B. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (600 mm) of backfill is in place, and again at completion of the Project.
   1. Submit separate reports for each system inspection.
   2. Defects requiring correction include the following:
      a. Alignment: Less than full diameter of inside of pipe is visual between structures.

b. Deflection: Flexible piping with deflection that prevents passage of a ball or cylinder of a size not less than 92.5 percent of piping diameter.
c. Crushed, broken, cracked, or otherwise damaged piping.
d. Infiltration: Water leakage into piping.
e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

C. Test new piping systems and parts of existing systems that have been altered, extended, or repaired for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to authorities having jurisdiction.
3. Schedule tests, and their inspections by authorities having jurisdiction, with at least 24 hours' advance notice.
4. Submit separate reports for each test.
5. Perform tests on lab and sanitary pressure sewer main as follows:
   a. Perform hydrostatic tests. The sanitary sewer and lab waste pipes shall be subjected to both pressure and leakage testing. Testing shall be performed by and Independent Testing Laboratory or by the Contractor subject to approval. Notify the Laboratory construction manager at least seven (7) days in advance of any hydrostatic test noted herein. Provide test reports for both pressure and leakage testing.
      i. Pressure Test: Comply with AWWA C600, AWWA 605, and IEPA requirements. Perform hydrostatic pressure test pipe after all joints and piping have been completed and installed. Provide partial backfill of trench leaving the joints exposed. The pipe shall be subject to a test pressure of 50 PSI or 150 percent the maximum operating working pressure, whichever is greater, for a period of 1 hour. Replace defective pipe, fittings, and joints with visible leaks.
      ii. Leakage Test: Comply with AWWA C600, AWWA 605, and IEPA requirements. The leakage test must be done subsequently to or concurrently with the pressure test. Duration of the leakage test shall be for a duration of two (2) hours in addition to the pressure test period noted above. Replace defective pipe, fittings, and joints with visible leaks. Allowable leakage in gallons per hour shall not be greater than as determined by the following equation:

$$L = \frac{SD\sqrt{P}}{148{,}000}$$

Where: L = testing (leakage) allowance, in gallons per hour
S = Length of pipe tested in feet
D = nominal diameter of pipe, inches
P = average test pressure during test, in pounds per square inch

6. Storm Drainage:
   a. Perform Field Test ASTM C 969 - "Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe."

b. Perform Field Test ASTM C 1103 - "Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines"

7. Retest per the requirements above if any deficiencies in the pipe, fittings, and joints are encountered during the hydrostatic testing.

END OF SECTION

SECTION 33 32 13
PACKAGED SEWAGE PUMPING STATIONS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes wet-well, packaged pumping stations with submersible grinder sewage pumps for both laboratory and sanitary waste lines.

1.02 RELATED DOCUMENTS

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

B. Section 33 31 00 – Sewerage Drainage

1.03 PERFORMANCE REQUIREMENTS

A. Pressure Rating of Sewage Pumps and Discharge Piping Components: At least equal to sewage pump discharge pressure.

B. Pressure Rating of Other Piping Components: At least equal to system operating pressure.

1.04 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Show fabrication and installation details for each packaged sewage pumping station. Detail equipment assemblies and indicate dimensions; shipping, installed, and operating weights; loads; required clearances; method of field assembly; components; electrical characteristics; and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Product Certificates: For each type of sewage pump, signed by product manufacturer.

D. Qualification Data: For Installer.

E. Source quality-control test reports.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For equipment to include in emergency, operation, and maintenance manuals.

1. Submit two (2) copies of a manual, containing installation instructions, operating instructions, wiring diagrams, parts list, and, where applicable, test data and curves.

H. Warranty: Special warranty specified in this Section.

I. Existing Lift Stations: Submit drawings and diagrams indicating work completed on existing lift stations. Drawings shall include elevations relative to the project datum and dimensions of existing lift station structures.

J. LEED Submittals:
1. LEED Credit MR 4.1 and Credit MR 4.2: Submit product data for products having recycled content, documentation indicating percentages by weight of post-consumer and pre-consumer recycled content.
   a. Include statement indicating costs for each product having recycled content.
2. LEED Credit MR 5.1 and Credit MR 5.2: Submit product data for products that have extracted, harvested, or recovered, as well as manufactured within 500 miles of the Project site.
   a. Include a statement indicating the percentage by weight which is extracted, harvested, or recovered within 500 miles of the Project site.

1.05 QUALITY ASSURANCE

A. Equipment Supplier: All controls, pumps, and motors shall be furnished by one equipment supplier. The equipment supplier shall have responsibility for the complete and proper operation of the new and existing pumping equipment, control equipment, and program as specified and furnished. The system supplier shall furnish 24-hour service for the complete system, and shall stock all parts used of the installation. Start-up services shall be included, and shall include operating instruction to the operators.

B. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with HI 1.1-1.2, "Centrifugal Pumps for Nomenclature and Definitions"; HI 1.3, "Centrifugal Pumps for Design and Application"; and HI 1.4, "Centrifugal Pumps for Installation, Operation and Maintenance," for sewage and sump pumps.

F. Comply with UL 778, "Motor-Operated Water Pumps," for sewage and sump pumps.

1.06 PROJECT CONDITIONS

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

1. Notify the Laboratory project manager not less than 14 calendar days in advance of proposed interruption of service.
2. Do not proceed with interruption of water-distribution service without the Laboratory project manager's written permission.

1.07 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

1.08 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged sewage pumping stations that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including shell.
b. Faulty operation of sewage pumps, controls, or accessories.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period for Shells: Manufacturer's standard warranty.
3. Warranty Period for Sewage Pumps and Controls: Manufacturer's standard warranty.
4. Warranty Period for Accessories: Manufacturer's standard warranty.

PART 2 - PRODUCTS

2.01 WET-WELL, PACKAGED SEWAGE PUMPING STATIONS

A. Wet-Well, Packaged Sewage Pumping Stations with Submersible Grinder Sewage Pumps:

1. Description: Factory fabricated, assembled, and tested with wet well for sewage pumps and collection of sanitary sewage and with sewage pumps and dry equipment chamber for controls and accessories.

2. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings and below:

a. Capacities and Characteristics:

i. Diameter: As indicated on Drawing.
ii. Height: As indicated on Drawing.
iii. Pumping Station, Inlet Pipe Size: 6 Inch Lab Waste, 4 Inch Sanitary
iv. Pumping Station, Discharge Pipe Size: 4 Inch Lab and Sanitary
v. Sewage Pumps: Two per station required.

b. Fiberglass lift station wet well and valve vault:

i. The filament wound fiberglass wet well shall have an inside diameter of 5 feet and a height as shown on the drawings. The basin shall have a steel, fiberglass coated, anti-floatation flange mounted on the bottom. Basin shall incorporate an outside valve vault, as described below. The basin shall have a coated steel cover encompassing both the wet well and valve vault, and provided with openings to bolt in the aluminum access hatches.

c. Lift station concrete foundation pad and anti-flotation collar:

i. Concrete shall be constructed in accordance with ACI 301. Concrete shall have a 28-day minimum compressive strength of 3,000 psi. Slump shall be between 2 and 4 Inches in accordance with ASTM C143. Provide joints as required by applicable ACI standards. Provide steel trowel finish for all exposed floor surfaces.
ii. All reinforcement shall be epoxy coated bars.

d. Lift Station Piping:

i. Lab Waste: 4” galvanized steel piping. All lab waste piping and valves shall be lined for corrosion resistance (pH range 6-9). Include product data for piping with lift station submittal.
ii. Sanitary Waste: 4” ductile iron.
iii. The piping shall terminate with a flange outside the basin wall for connection to the valves in an external valve vault. The valve vault shall include two (2) 4" wafer check valves and three (3) 4" plug valves. A third plug valves shall be for use with a by-pass riser and quick disconnect hose coupling for portable pump connection, as shown on the plans. Inlet or inlets into basin shall have rubber boots for inlet pipe diameter, as shown on the plans. The pump guide rails shall be 1.5" stainless steel pipe. Intermediate guide rail supports shall be used if basin is more than 15 feet deep.

e. Metal-to-Metal Rail System:

i. The MTM rail system shall include a discharge base elbow, sealing flange with rail guide, upper guide bracket, stainless steel lifting chain, and stainless steel guide rails. The discharge base elbow shall have mounted directly on the sump floor and sized according to the plans. It shall have a standard 125 lb flange, with machined face. The design shall be such that the pump to discharge connection is made without the need for any nuts, bolts, or gaskets. The base elbow shall also anchor two (2) 1.5" stainless steel guide rails.

ii. The sealing flange/rail guide bracket shall be mounted on each pump discharge. It shall have a machined mating flange which matches the base elbow discharge connection. Sealing of this discharge connection shall be accomplished by simple linear downward motion of the pump culminating with the entire weight of the pumping unit supported entirely by the base elbow.

iii. The upper guide bracket shall align and support the two guide rails at the top of the sump. It shall bolt directly to the hatch frame and incorporate an expandable rubber grommet. Each pump shall be provided with a stainless steel lifting chain, and be of sufficient length to extend from the pump to the top of the wet well. The access frame shall provide a hook to attach the chain when not in use. The lifting chain shall be sized according to the pump weight.

f. Access frame and cover:

i. A double door access frame assembly shall be supplied for the wet well and a single access door assembly shall be supplied for the valve vault. Access frame and covers shall be fabricated of aluminum and bolted to basin. Frame shall support guide rails and electrical wiring bracket. A separate hinged cover shall be provided for each pump. Cover shall be provided with lifting handle and safety latch to hold cover in the open position. Locking hasps shall be furnished for each cover.

g. Sump Pump:

i. A sump pump shall be provided for dewatering the valve vault back to the wet well. The pump shall be equipped with a 1/3 hp, 1 phase, 60 Hz, 115v motor designed for automatic operation through a piggy-back diaphragm switch. The pump discharge shall be 1-1/2”.

h. Submersible Pumps:

i. Two submersible-type sewage pumps per lift station, with guide rail, quick-disconnect system, controls, and piping. Provide a hermetically sealed motor with moisture-sensing probe, mechanical seals, and waterproof power cable.

ii. Include ASTM A48/A 48M, Class 25, nonclog, stainless steel impeller capable of passing solids of 3-inch minimum diameter.

iii. Pump suction and discharge openings shall be no less than 3” diameter.

iv. Pump casings shall be fitted with a bronze wear ring. Pumps shall have two mechanical seals with oil chamber between the seals. Rotational seal faces shall be carbon, and stationary seal faces shall be ceramic.

v. All lifting loads will be on the guide supports and not on the pump or motor housing. A lifting chain and hook shall be supplied for each pump.

vi. Each pump motor shall be provided with heat sensing units, which shall trip the starter if the motor overheats.

vii. The seal chamber shall be fitted with an electrode probe to detect water in the seal chamber and indicated by seal fail lights on the control panel.

viii. Lab Waste Submersible pumps: provide polymer coating for corrosion resistance inside and outside of each pump. Polymer coating shall be capable of withstanding liquid with a pH range of 6-9.

ix. Capacity of Each Sewage Pump:

a) Lift Station #1 Lab Waste: 120 GPM @ 16.8 feet TDH
b) Lift Station #2 Sanitary Waste: 120 GPM @ 18.5 feet TDH

x. Speed:

a) Lift Station #1 Lab Waste: 1140 RPM
b) Lift Station #2 Sanitary: 1140 RPM

xi. Motor Size: 4 hp.

xii. Pump Electrical Characteristics:

a) Volts: 460 V.
b) Phases: Three.
c) Hertz: 60.

xiii. Pump electrical cords and accessories:

a) Pump motor cords shall be designed for flexibility and serviceability under hard usage conditions and meets the NEC requirements for sewage lift stations. The electrical system shall include ground fault protection in accordance with NEC and de-energize the circuit in the event of electrical integrity failure. The power cable entry into the cord cap assembly shall first be made with a compression fitting. Each individual lead shall be stripped sown to bare wire, at staggered intervals, and each strand shall be individually separated. This area of the cord cap shall then be fitted with an epoxy compound potting which will prevent water contamination to gain entry even in the event of wicking or capillary attraction. There shall be an additional epoxy compound potting area separating the motor housing from the cord cap assembly for added protection. The cord cap shall be capable of removing and disconnecting the

motor connections for pump removal, repair or replacement without disturbing the motor.

b) A stainless steel wiring bracket shall provide cord grip holders for the pump cords and the control cords. All cords shall extend from bracket through conduit to control box. No splices shall be made in the wiring. Continuous cords must be used from control panel to pumps and controls. Wiring bracket shall be fastened to access frame.

2.02 LIFT STATION CONTROLS

A. All equipment under this specification shall be furnished by a single manufacturer which shall have sole responsibility for proper functioning of the integrated control system. The control system manufacturer shall have on staff a minimum of one registered professional engineer (P. E.). In order to establish a level of quality, the entire system shall be manufactured, serviced, and warranteed by the scheduled manufacturer.

B. Duplex transducer based wet-well level control system characteristics:

1. NEMA-4 enclosure: Provide a single enclosure power and control panel, in a NEMA-4 enclosure per lift station. A NEMA-4X Red Lexan flashing alarm-light shall be mounted on the top exterior of the enclosure. The outer door of the panel shall include padlocking provisions. The panel shall have a leg kit for mounting to a concrete pad. All of the control panel components specified herein shall be factory internally pre-wired and tested in accordance with the provisions of the National Electrical Code. The following devices shall be mounted through the door, or shall be accessible without the need to open the inner door:

   a. One (1) Color Touch-Surface operator interface panel.
   b. Two (2) pump-run lights.
   c. Two (2) pump hand-off-auto selector switches.
   d. Two (2) pump-power circuit-breakers.
   e. Two (2) pump current overload lights.
   f. Two (2) pump current overload-reset push-buttons.
   g. One (1) control-mode float-transducer-auto selector switch.
   h. One (1) float-backup engaged light.
   i. Two (2) pump elapsed running-time meters.

2. The protected internal portion of the control panel shall include the following:

   a. One (1) 3-phase, main-power disconnect switch.
   b. One (1) 3-phase power-distribution block.
   c. Two (2) 3-phase thermal magnetic circuit breakers.
   d. Two (2) 3-phase across the line starters.
   e. Two (2) 3-phase adjustable class-10 current overload-blocks with through-the-door reset push-buttons.
   f. One (1) 3-phase power monitor, capable of monitoring loss of phase, low-voltage, high-voltage, voltage-imbalance, phase-reversal & rapid-cycling.)

3. The enclosure shall also house all other necessary control components, including but not limited to:

    a. One (1) control-circuit transformer with separately-fused primary, and fused 120-volt secondary & control power switch.
    b. Two (2) seal-fail modules with adjustable sensitivity.
    c. One (1) anti-condensation convection-type space-heater with fully-adjustable thermostat.
    d. One (1) controller-service power-disconnect switch.
    e. One (1) 24Vdc power-supply unit.
    f. One (1) programmable logic controller (PLC).

4. Color Touch-Surface Operator Interface Panel: the color touch-surface operator interface panel shall be manufactured to the following design criteria & capabilities per lift station:

    a. Capable of displaying a minimum of 65,500-colors.
    b. An LCD display.
    c. An LED backlight.
    d. One (1) USB Host version 1.1/1
    e. Three (3) serial COM ports.
    f. Built-In perpetual calendar.
    g. 24Vdc operating voltage.
    h. 3V lithium battery back-up.
    i. 5.6” Diagonal touch-surface, with a resolution of 320 x 234-Pixels, and Flash ROM of 4MB.

5. Programmable Logic Controller (PLC): The PLC shall be powered by an individual 24Vdc power supply unit. The PLC shall be manufactured to the following design criteria & capabilities per lift station:

    a. Non-volatile battery-backed RAM.
    b. Built-in back-up memory storage module.
    c. 10K user program space.
    d. 10K configurable user data space.
    e. 128K data logging & recipe storage.
    f. Twelve (12) 24Vdc fast digital inputs.
    g. Eight (8) 24Vdc normal digital inputs.
    h. Six (6) digital relay outputs.
    i. Three (3) dc fast digital outputs.
    j. Three (3) dc normal digital outputs.
    k. Four (4) analog voltage inputs.
    l. Two (2) analog voltage outputs.
    m. One (1) isolated combination RS232C/RS485 serial port.
    n. One (1) non-isolated RS232C serial port.
    o. One (1) RJ-45 10/100 EtherNet/IP port.
    p. Two (2) digital trim potentiometers.
    q. Up to six (6) embedded high speed input channels @ 100kHz.
    r. Embedded perpetual real-time clock.

s. PID control.
t. 3-channel PTO (100 kHz)/PWM (40 kHz).
u. Dual axis servo control.
v. Embedded LCD with backlight.
w. Floating point math values.
x. Online editing.
y. Operating temperature range of -4°F -to- 140°F

6. The programmable logic controller shall be pre-programmed at the manufacturer's facility, to perform the following major functions, as well as various additional functions, as referenced in the paragraphs which follow. The system shall operate based on operator adjustable preferences entered via the menu-keys displayed on the touch-surface operator interface panel. The major functions are as follows:

a. Monitor & display real-time wet-well liquid-level, and manage pump operation based on user-selected set-point programming.
b. Operate one (1) pump during low-level flow periods; operate two (2) pumps during high-level flow periods.
c. Alternate the two pumps on operator selected time-intervals.
d. Monitor & delay pump-starts to avoid short-cycling motors.
e. Monitor & delay pump-starts to avoid simultaneous starting of pumps following utility power losses.
f. Monitor & recognize inoperable level sensing devices, and modify system operation to compensate for this occurrence.
g. Provide easily identifiable alarm messages for the operating personnel to monitor.
h. Monitor embedded pump-motor thermal-sensors, when wired.

C. Level Monitoring in the wet-well: A primary submersible level transducer shall be provided & utilized as the pilot device for use in monitoring the level of the liquid in the wet-well, and shall provide 4-20mA signal to the PLC. The system shall also incorporate circuitry designed to monitor float-operated level-switches as back-up level control mechanisms, to operate pumps & level-alarms during failure of the level transmitter and/or PLC. The control system shall utilize four (4) suspended level-switches with normally-open contacts, which shall be used to monitor and control the liquid level within the wet-well.

1. Operation of system when utilizing four (4) level-switches: The level-switch installed in the lowest position in the wet-well shall shut-off all pumps. The next highest level-switch from the bottom shall start one pump and shall trigger alternation of the two (2) pumps on each successive cycle of operation. The third level-switch from the bottom shall start both pumps or start the second pump if the first pump fails for any reason. The fourth switch shall be located at the highest point, typically at the invert elevation of the wet-well inlet, and shall signal a high wet-well level alarm. All level-switches shall be removable through a wet-well access opening.

D. Initiating Operation: The color touch-surface operator interface panel shall be preprogrammed at the manufacturer's facility, allowing the field operating personnel to answer five (5) or fewer questions with simple one-word answers, in order to enable the control logic the ability to initiate the proper mode of preconfigured automatic operation of the pump station.

1. The color touch-surface operator interface panel shall provide additional simple screen-selections, allowing the operating personnel to select the appropriate operating parameters for the following categories:

a. Lead-pump start & stop elevations.
b. Lag-pump start & stop elevations.
c. Lead/Lag pump alternation time-interval
d. High liquid-level alarm elevation.
e. Low liquid-level alarm elevation.
f. Individual pump start & stop delay-times – Lead/Lag.
g. Individual pump stage delay-times – Lead/Lag.
h. Individual pump fail indication delay-times – Lead/Lag.
i. High liquid-level alarm indication delay-time.
j. Low liquid-level alarm indication delay-time.
k. High flow-rate alarm indication delay-time.
l. Float back-up reset delay-time.
m. Primary level-transducer scale-definition in feet of elevation.
n. Back-up level-transducer scale-definition in feet of elevation.
o. Level-transducer flow-rate scale-definition in gallons per minute.
p. Selection of primary -vs- secondary level-transducer.
q. Level display elevation.

2. In addition, the color touch-surface operator interface panel shall provide additional simple screen-selections, allowing the operating personnel to monitor the following categories:

a. Real-Time wet-well liquid-level elevation.
b. Current pump-station flow-rate.
c. Daily pump-station flow-rate.
d. Pump-station flow-rate totalizer.
e. Individual pump on-off status – P-1/P-2.
f. Individual pump running-time – P-1/P-2.
g. Data log graph of alarm history.
h. Data log graph of wet-well level trend – Primary transducer.
i. Data log graph of wet-well level trend – Secondary transducer.
j. Data log graph of wet-well flow-rate.

E. Remote Monitoring: The control panel shall have the ability to connect to the buildings BAS system.

1. The following remote monitoring devices shall be included per lift station:

a. One (1) set: common-alarm dry contacts.
b. One (1) set: common pump-fail alarm dry contacts.
c. One (1) set: valve-vault flood alarm dry contacts.
d. One (1) set: transducer-fail alarm dry contacts.
e. One (1) set: high wet-well level alarm dry contacts.
f. One (1) set: low wet-well level alarm dry contacts.
g. One (1) set: power-fail alarm dry contacts.

2.03 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 6/A 6M, W or HP shapes, or ASTM A 36/A 36M, plates or beams.

B. Grout: ASTM C 1107, Grade B, nonshrink cement grout.

1. Design Mix: 5000-psi , 28-day compressive strength.

2.04 SOURCE QUALITY CONTROL

A. Test and inspect sewage and sump pumps according to HI 1.6, "Centrifugal Pump Tests." Include test recordings that substantiate correct performance of pumps at design head, capacity, suction lift, speed, and horsepower.

B. Test accessories and controls through complete cycle. Include test recordings that substantiate correct performance.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of sewerage piping systems to verify actual locations of piping connections before packaged sewage pumping station installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earthwork."

3.03 INSTALLATION

A. Install packaged sewage pumping station components where indicated, according to specific equipment and piping arrangement indicated.

3.04 CONNECTIONS

A. Sanitary sewer piping installation requirements are specified in Division 33 Section "Site Underground Utilities." Drawings indicate general arrangement of piping.

B. Install piping adjacent to machine to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding."

D. Connect wiring according to Division 26 Section "Conductors and Cables."

3.05 IDENTIFICATION

A. Install identifying labels permanently attached to equipment.

B. Install operating instruction signs permanently attached to equipment or on pumping station wall near equipment.

C. Arrange for installing green detectable warning tape over outside edges of underground packaged sewage pumping stations. Tape materials and their installation are specified in Division 31 Section "Earthwork."

3.06 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. After installing packaged sewage pumping stations and after electrical circuitry has been energized, test for compliance with requirements. Furnish water required for pump tests.
2. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace packaged sewage pumping stations that do not pass tests and inspections and retest as specified above.

3.07 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Adjust pump, accessory, and control settings, and safety and alarm devices.

3.08 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged sewage pumping stations.

END OF SECTION 33 32 1

SECTION 33 46 00
SUBDRAINAGE

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 RELATED WORK

A. 31 23 33 – Trenching and Backfilling
B. 33 31 00 – Sewerage and Drainage

1.03 SUMMARY

A. Section Includes:
1. Perforated-wall pipe and fittings.
2. Geotextile filter fabrics.

1.04 SUBMITTALS

A. Product Data:
1. Drainage pipe and connections: Submit manufacturer's descriptive literature, detailed specifications and recommendations for installation, including jointing.
2. Geotextile filter fabrics: Submit manufacturer's descriptive literature, detailed specifications, performance test data, instructions, and recommendations for installation of geotextile fabrics.
3. Drainage aggregate: Submit gradation conforming to IDOT standards, as specified in the drawings.

1.05 QUALITY CONTROL

A. Testing and Inspection Service:
1. The using agency shall engage in testing and inspection service to perform sampling and testing of in place soil materials for quality control during earthwork operations at no cost to the Contractor for the testing or inspection.
2. Laboratory Tests:
   a. Test Granular Backfill materials for gradation prior to use. Test at least one sample for each material source.
   b. Test "Granular Backfill" and "General Backfill" materials for maximum compacted density and optimum moisture content in accordance with ASTM D1557 if possible with specified material. Test at least one sample for each source.
   c. After testing, the testing laboratory shall inform Using Agency in writing of its recommendations for compaction of the soil samples submitted for testing. One copy of each report will be sent to the Contractor and A/E. The Contractor shall comply with such recommendations.

B. Field Test Controls:

1. Perform in-place density tests in randomly selected locations an in accordance with ASTM D1556 (sand cone method) or ASTM D2922 and ASTM D3017 (nuclear methods) as follows:

	Material Type	Test Frequency
(1)	Granular Backfill	one per lift per 400 lineal feet of line
(2)	General Backfill	one per lift per 400 lineal feet of line

1.06 DELIVERY AND STORAGE: Deliver and store materials in a manner to prevent contamination or segregation.

1.07 SITE CONDITIONS

A. Protection of Persons and Property

1. Barricade open excavations occurring as part of this work and post with warning lights. Operate warning lights as recommended by authorities having jurisdiction.
2. Protect utilities, pavements and other facilities from damages caused by settlement, lateral movements, undermining, wash-out and other hazards created by excavation operations.

PART 2 - PRODUCTS

2.01 PIPES FOR UNDERDRAINS

A. Smooth Plastic Pipe

1. Solid and perforated Polyvinyl Chloride (PVC) subsurface drain pipe and fittings, meeting requirements of ASTM D3034, SDR 26.
2. Perforated Pipe must have silt sock.

2.02 CLEANOUTS

A. Riser piping for outside the building: PVC soil pipe complying with ASTM D2665.

B. Cleanout plug: Threaded PVC plug to fit bell end of riser pipe.

C. Housing: Cast iron or PVC, round, flanged, as noted on Drawings.

2.03 DRAINAGE AGGREGATE

A. Conform to IDOT CA-7.

2.04 SOIL MATERIALS

A. Soil materials are specified in Division 31 Section "Earthwork."

2.05 GEOTEXTILE FILTER FABRICS

A. Geotextile Filter Fabric: A nonwoven fabric consisting of previous sheets of propylene, nylon, polyester, or ethylene yarn. Certify material by manufacturer to meet the following requirements. Pre-assembled silt fencing may be substituted if it meets the below requirements.

	Property	Test Method	Requirements
1.			
2.	Minimum Tensile Strength	ASTM D4632	90 lb
3.	Maximum Elongation at 45 lb	ASTM D4632	50% Max
4.	Apparent Opening Size	ASTM D4751	AOS<0.60 mm
5.	Minimum Permittivity	ASTM D4491	1x10-2 SEC -1
6.	Ultraviolet Exposure Strength Retention	ASTM D4355	70% @ 500h

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.

B. If subdrainage is required for landscaping, locate and mark existing utilities, underground structures, and aboveground obstructions before beginning installation and avoid disruption and damage of services.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 TRENCH EXCAVATION

A. Trenches shall be excavated so the underdrains may be placed correctly on line and grade. Large rocks, stumps, masses of concrete and other materials encountered in the trench shall be completely removed from the trench, and shall not be used for backfill. Utilities and surface structures shall be protected by the Contractor to assure their safety from damage. Keep trenches free from water while construction is in progress.

B. Grade bottom of trenches accurately to provide uniform bearing and support for each section of pipe.

C. Filter fabric shall be placed in the trench and covered with drainage aggregate to the depth shown on the drawings. Fabric length shall be sufficient to completely wrap drainage aggregate with a minimum lap of 6 inches.

3.03 LANDSCAPING DRAINAGE INSTALLATION

A. Provide trench width to allow installation of drainage conduit. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches.

D. Install drainage conduits as indicated in Part 3 "Piping Installation" Article for landscaping subdrainage with horizontal distance of at least 6 inches between conduit and trench walls. Wrap drainage conduits without integral geotextile filter fabric with flat-style geotextile filter fabric before installation. Connect fabric sections with tape.

E. Add drainage course to top of drainage conduits.

F. After satisfactory testing, cover drainage conduit to within 12 inches of finish grade.

G. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.

H. Fill to Grade: Place satisfactory soil fill material over drainage course. Place material in loose-depth layers not exceeding 6 inches. Thoroughly compact each layer. Fill to finish grade.

3.04 PIPING INSTALLATION

A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.
   1. Landscaping Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.50% and with a minimum cover of 30 inches unless otherwise indicated.
   2. Lay perforated pipe with perforations down.
   3. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.

B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.

C. Install thermoplastic piping according to ASTM D 2321.

3.05 PIPE JOINT CONSTRUCTION

A. Join perforated PE pipe and fittings with couplings according to ASTM D 3212 with loose banded, coupled, or push-on joints.

B. Join perforated PVC sewer pipe and fittings according to ASTM D 3212 with loose bell-and-spigot, push-on joints.

C. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

3.06 CLEANOUT INSTALLATION

A. Comply with requirements for cleanouts specified in Section "Underground Site Utilities."

B. Cleanouts for Landscaping Subdrainage:
   1. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
   2. In nonvehicular-traffic areas, use NPS 4 (DN 100) PVC pipe and fittings for piping branch fittings and riser extensions to cleanout. Set top of cleanout at grade elevation.

3.07 CONNECTIONS

A. Comply with requirements for piping specified Section "Underground Site Utilities." Drawings indicate general arrangement of piping, fittings, and specialties.

A. Connect low elevations of subdrainage system to solid-wall-piping storm drainage system.

B. All underdrainage piping entering drainage structures shall have flexible water-tight seals at structure walls.

3.08 CLEANING

A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION