PROJECT MANUAL

For

SBN FAR DETECTOR BUILDING
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

Fermilab

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SPECIFICATION DIVISIONS 00 THROUGH 17

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SECTION 01524 - CONSTRUCTION WASTE MANAGEMENT AND RECYCLING

PART 1. GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

2. Construction waste recycling.

1.03 PLAN REQUIREMENTS

A. Develop, submit, and implement a Construction Waste Management plan to recycle or salvage at least 50 percent of the non-hazardous construction, demolition and land clearing materials, excluding soil, for compliance with DOE Guiding Principle.

1.04 SUBMITTALS

A. Construction Plan: Submit construction waste management plan describing methods and procedures for implementation and monitoring compliance including the following:

1. Transportation company hauling construction waste to waste processing facilities.
2. Recycling and adaptive reuse processing facilities and waste type each facility will accept.
3. Construction waste materials anticipated for recycling and adaptive reuse.
4. On site sorting and site storage methods.

B. Submit documentation prior to Substantial Completion, substantiating construction waste management plan was maintained and goals were achieved.

1. Trash: Quantity by weight deposited in landfills. Include associated fees, transportation costs, container rentals, and taxes for total cost of disposal.

2. Salvaged Material: Quantity by weight with destination for each type of material salvaged for resale, recycling, or adaptive reuse. Include associated fees, transportation costs, container rentals, and taxes for total cost of disposal. Also include reimbursements due to salvage resale.
3. Total Cost: Indicate total cost or savings for implementation of construction waste management plan.

1.05 CONSTRUCTION WASTE MANAGEMENT PLAN

A. Construction Waste Landfill Diversion: Minimum 50 percent by weight of construction waste materials for duration of Project through resale, recycling, or adaptive reuse.

B. Implement construction waste management plan at start of construction.

C. Review construction waste management plan at pre-construction meeting and progress meetings.

D. Distribute approved construction waste management plan to subcontractors and others affected by Plan Requirements.

E. Oversee plan implementation, instruct construction personnel for plan compliance, and document plan results.

1.06 CONSTRUCTION WASTE RECYCLING

A. The Contractor shall have the option of sorting the materials off-site or on-site.

1. Off-Site: If the Contractor chooses to sort the material off-site, he shall provide the name of the vendor, and provide procedures on the documentation of the recyclable waste.

2. On-Site: The contractor shall provide separate collection containers for a minimum of the following materials:

a) Untreated lumber.

b) Gypsum wallboard.

c) Paper, paper products, and cardboard.

d) Plastics.

e) Metals.

f) Glass.

g) Other salvageable materials.

1.07 CONSTRUCTION WASTE ADAPTIVE RE-USE

A. Arrange with processing facility for salvage of construction material and processing for reuse. Do not reuse construction materials on site except as accepted by Owner.

1.08 QUALITY ASSURANCE
A. Regulatory Requirements: Comply with applicable local ordinances and regulations

B. Disposal Sites, Recyclers, and Waste Materials Processors: Use only facilities properly permitted by the State of Illinois, and by local authorities where applicable.

C. Prior to beginning work at the site, schedule and conduct a conference to review the Construction Waste Management Plan and discuss procedures, schedules and specific requirements for waste materials recycling and disposal. Discuss coordination and interface between the Subcontractor and other construction activities. Identify and resolve problems with compliance with requirements. Record minutes of the meeting, identifying all conclusions reached and matters requiring further resolution.

1. Attendees: The Subcontractor and related Subcontractor personnel associated with the work of this section, including personnel to be in charge of the waste management program; the Construction Quality Manager; CC; and such additional personnel as Fermilab deems appropriate.

2. Plan Revision: Make any revisions to the Construction Waste Management Plan agreed upon during the meeting and incorporate resolutions agreed to be made subsequent to the meeting. Submit the revised plan to Fermilab for approval.

D. Implementation: Designate an on-site person responsible for instructing workers and implementing the Construction Waste Management Plan. Distribute copies of the Construction Waste Management Plan to the job site foreman and each subcontractor. Post Waste Management Plan on the job site bulletin board. Include waste management and recycling in worker orientation and review periodically. Provide on-site instruction on appropriate separation, handling, recycling, and salvaging methods to be used by all parties at the appropriate stages of the work at the site. Include waste management and recycling discussion in pre-fabrication meetings with subcontractors and fabricators. Also include discussion of waste management and recycling in regular job meetings and job safety meetings conducted during the course of work at the site.

PART 2. PRODUCTS - Not Used

PART 3. EXECUTION

3.01 CONSTRUCTION WASTE COLLECTION

A. Collect construction waste materials in marked bins or containers and arrange for transportation to recycling centers or adaptive salvage and reuse processing facilities. Remove all indicated recyclable materials from the work location to approved containers daily. Failure to remove waste materials will be considered cause for withholding payment and termination of Contract
B. Change out loaded containers for empty ones as demand requires, but not less than weekly.

C. Handling: Deposit all indicated recyclable materials in the containers in a clean (no mud, adhesives, solvents, petroleum contamination), debris-free condition. Do not deposit contaminated materials into the containers until such time as such materials have been cleaned.

D. If the contamination chemically combines with the material so that it cannot be cleaned, do not deposit into the recycle containers. In such case, request resolution by the Construction Quality Manager as to disposal of the contaminated material. Directions from the Construction Quality Manager do not relieve the Subcontractor from compliance with all legal and regulatory requirements for disposal, nor shall such directions cause a request for modification of the Contract.

E. Maintain recycling and adaptive reuse storage and collection area in orderly arrangement with materials separated to eliminate co-mingling of materials required to be delivered separately to waste processing facility.

F. Store construction waste materials to prevent environmental pollution, fire hazards, hazards to persons and property, and contamination of stored materials.

G. Cover construction waste materials subject to disintegration, evaporation, settling, or runoff to prevent polluting air, water, and soil.

3.02 CONSTRUCTION WASTE DISPOSAL

A. Deliver construction waste to waste processing facilities. Obtain receipt for deliveries.

B. Dispose construction waste not capable of being recycled or adaptively reused by delivery to landfill, incinerator, or other legal disposal facility. Obtain receipt for deliveries.

END OF SECTION 01524
SECTION 01805 – GENERAL REQUIREMENTS – DOE GUIDING PRINCIPLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements and procedures for compliance with U.S. Department of Energy’s Guiding Principles for New Construction. The goal of these Guiding Principles for Sustainable Buildings is to design buildings to be energy efficient, conserve resources, and provide comfortable and healthy environments for occupants.

B. Guiding Principles Items incorporated into the Design:

1. Commissioning
2. Energy Efficiency
3. Measurement and Verification
4. Indoor Water – Water Savings
5. Indoor Water – Measurement and Verification
6. Water Efficient Products
7. Ventilation and Thermal Control
8. Moisture Control
9. Day-lighting
10. Day-lighting – Lighting Controls

C. Guiding Principles Items to be incorporated during Construction:

1. Commissioning
2. Low-emitting Materials
3. Air Quality during Construction
4. Recycled Content
5. Bio-based Content
6. Environmentally Preferable Products
7. Waste and Materials Management
8. Ozone Depleting Compounds

1.2 DEFINITIONS

A. Regional Materials: Materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site. If only a fraction of a product or material is extracted/harvested/recovered and manufactured locally, then only that percentage (by weight) shall contribute to the regional value.

B. Recycled Content: The recycled content value of a material assembly shall be determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.
1. "Post-consumer" material is defined as waste material generated by households or by commercial, industrial, and institutional facilities in their role as end users of the product, which can no longer be used for its intended purpose.

2. "Pre-consumer" material is defined as material diverted from the waste stream during the manufacturing process. Excluded is reutilization of materials such as rework, regrind, or scrap generated in a process and capable of being reclaimed within the same process that generated it.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Respond to questions and requests from Fermilab regarding Guiding Principles Construction Items that are the responsibility of the Contractor, that depend on product selection or product qualities, or that depend on Contractor's procedures. Document responses as informational submittals.

1.4 ACTION SUBMITTALS

A. General: Compliance with the requirements of the Guiding Principles goals shall be clearly indicated on the action submittals required by other Specification Sections.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Provide products and procedures necessary to comply with Guiding Principles outlined in this Section. Although other Sections may specify some requirements that contribute to compliance with the Guiding Principles, the Contractor shall determine additional materials and procedures necessary to comply.

2.2 COMMISSIONING

A. Objective: To employ commissioning tailored to the building, including commissioning requirements in construction documents, a commissioning plan, verification and a final report.

B. Implementation:

1. Refer to specification section 01815 – General Commissioning Requirements
2. Refer to Specification section 15995 – Commissioning of HVAC Systems

2.3 LOW-EMITTING MATERIALS

A. Objective: Use materials and products inside the weatherproofing system of the building that have low pollutant emissions, including composite wood products, adhesives, sealants, interior paints and finishes, carpet systems, and furnishings.
B. Implementation: All submittals

1. Adhesives and Sealants shall comply with the following VOC content limits when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

   a) Wood Glues: 30 g/L.
   b) Metal-to-Metal Adhesives: 30 g/L.
   c) Adhesives for Porous Materials (Except Wood): 50 g/L.
   d) Subfloor Adhesives: 50 g/L.
   e) Plastic Foam Adhesives: 50 g/L.
   f) Carpet Adhesives: 50 g/L.
   g) Carpet Pad Adhesives: 50 g/L.
   h) VCT and Asphalt Tile Adhesives: 50 g/L.
   i) Cove Base Adhesives: 50 g/L.
   j) Gypsum Board and Panel Adhesives: 50 g/L.
   k) Rubber Floor Adhesives: 60 g/L.
   l) Ceramic Tile Adhesives: 65 g/L.
   m) Multipurpose Construction Adhesives: 70 g/L.
   n) Fiberglass Adhesives: 80 g/L.
   o) Contact Adhesive: 80 g/L.
   p) Structural Glazing Adhesives: 100 g/L.
   q) Wood Flooring Adhesive: 100 g/L.
   r) Structural Wood Member Adhesive: 140 g/L.
   s) Single-Ply Roof Membrane Adhesive: 250 g/L.
   t) Special-Purpose Contact Adhesive (contact adhesive that is used to bond melamine-covered board, metal, unsupported vinyl, rubber, or wood veneer 1/16 inch or less in thickness to any surface): 250 g/L.
   u) Top and Trim Adhesive: 250 g/L.
   v) Plastic Cement Welding Compounds: 250 g/L.
   w) ABS Welding Compounds: 325 g/L.
   x) CPVC Welding Compounds: 490 g/L.
   y) PVC Welding Compounds: 510 g/L.
   z) Adhesive Primer for Plastic: 550 g/L.
   aa) Sheet-Applied Rubber Lining Adhesive: 850 g/L.
   cc) Aerosol Adhesive, General-Purpose Web Spray: 55 percent by weight.
   dd) Special-Purpose Aerosol Adhesive (All Types): 70 percent by weight.
   ee) Other Adhesives: 250 g/L.
   ff) Architectural Sealants: 250 g/L.
   gg) Nonmembrane Roof Sealants: 300 g/L.
   hh) Single-Ply Roof Membrane Sealants: 450 g/L.
   ii) Other Sealants: 420 g/L.
   jj) Sealant Primers for Nonporous Substrates: 250 g/L.
   kk) Sealant Primers for Porous Substrates: 775 g/L.
   ll) Modified Bituminous Sealant Primers: 500 g/L.
   mm) Other Sealant Primers: 750 g/L.
2. Paints and Coatings shall comply with the following VOC content limits when calculated according to 40 CFR 59, Subpart D (EPA Method 24):
   a) Categories in subparagraphs below are taken from LEED rating systems and the standards referenced by them; if clarification is required, see those documents or the reference guides.
   b) Flat Paints and Coatings: VOC not more than 50 g/L.
   c) Nonflat Paints and Coatings: VOC not more than 150 g/L.
   d) Dry-Fog Coatings: VOC not more than 400 g/L.
   e) Primers, Sealers, and Undercoaters: VOC not more than 200 g/L.
   f) Anticorrosive and Antirust Paints Applied to Ferrous Metals: VOC not more than 250 g/L.
   g) Zinc-Rich Industrial Maintenance Primers: VOC not more than 340 g/L.
   h) Pretreatment Wash Primers: VOC not more than 420 g/L.
   i) Clear Wood Finishes, Varnishes: VOC not more than 350 g/L.
   j) Clear Wood Finishes, Lacquers: VOC not more than 550 g/L.
   k) Floor Coatings: VOC not more than 100 g/L.
   l) Shellacs, Clear: VOC not more than 730 g/L.
   m) Shellacs, Pigmented: VOC not more than 550 g/L.
   n) Stains: VOC not more than 250 g/L.

3. Composite wood, agrifiber products, and adhesives shall not contain urea-formaldehyde resin.
   a. Also refer to section 06412 Plastic Laminate Faced Architectural Cabinets and section 06417 – Plastic Laminate Clad Countertops.

2.4 AIR QUALITY DURING CONSTRUCTION


B. Implementation:

1. Refer to specification section 01572 – Indoor Air Quality During Construction

2.5 RECYCLED CONTENT OF MATERIALS

A. Objective: Building materials shall have recycled content such that post-consumer recycled content plus one-half of pre-consumer recycled content for Project constitutes a minimum of 10, but possibly as much as 20 percent of cost of materials used for Project.

1. Cost of post-consumer recycled content plus one-half of pre-consumer recycled content of an item shall be determined by dividing weight of post-consumer recycled content plus one-half of pre-consumer recycled content in the item by total weight of the item and multiplying by cost of the item.

2. Do not include furniture, plumbing, mechanical and electrical components, and specialty items such as elevators and equipment in the calculation.
B. Implementation: Select suppliers and vendors for the following materials that will make the project meet the target:

1. Cast-in-Place Concrete
2. Concrete Reinforcing
3. Structural and Miscellaneous Steel
4. Metal Wall and Roofing Systems
5. Metal Doors and Frames
6. Glazing
7. Aluminum Framed Windows and Curtain-walls
8. Metal Stud Framing
9. Gypsum Board

C. Additional Requirements in specific sections:
1. Refer to section 02370 – Erosion Control – for Riprap
2. Refer to section 09580 – Suspended Decorative Grid Ceiling.

2.6 BIOBASED CONTENT

A. Objective: Use Building materials that use biobased carbon content in lieu of fossil carbon content (coal or petroleum).

B. Implementation: Select suppliers and vendors for the following materials that will make the project meet the target:

1. Paving and Concrete Forming
2. Lumber and Millwork
3. Paintings and Coatings
4. Sealants

2.7 ENVIRONMENTALLY PREFERABLE PRODUCTS

A. Objective: Use Building materials that have less impact on human health and the environment over their lifecycle.

B. Implementation: Refer to sections above:

1. Low-emitting Materials
2. Recycled Material Content
3. Biobased content

2.8 WASTE AND MATERIALS MANAGEMENT

A. Objective: Recycle at least 50% of Construction waste during construction.

B. Implementation:

1. Refer to section 01524 – Construction Waste Management and Recycling.
2.9 OZONE DEPLETING COMPOUNDS

A. Objective: Eliminate the use of ozone-depleting compounds during and after construction. Do not use materials containing CFC or HCFC compounds. Do not use equipment using CFC refrigerants.

B. Implementation:

1. Refer to section 07413 – Insulated-Core Metal Wall Panels
2. Refer to section 15083 – HVAC Insulation
3. Refer to section 15085 – Plumbing Piping Insulation
4. Refer to section 15427 – Pressure Water Coolers
5. Refer to section 15732 – Packaged, Outdoor, Central-Station Air-Handling Units

PART 3 - EXECUTION (NOT USED)

END OF SECTION 01810
SECTION 01810 - COMMISSIONING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description
B. Commissioning Process
C. Related Work

1.2 DESCRIPTION

A. Commissioning. Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the Owner’s operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing, adjusting and balancing, performance testing and training.

B. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:

1. Verify applicable equipment and systems are installed according to the Owner’s Project Requirements, manufacturer’s recommendations, and industry accepted minimum standards.
2. Verify applicable equipment and systems receive adequate operational checkout by installing contractors.
3. Observe and document proper performance of equipment and systems.

C. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

D. Abbreviations. The following are common abbreviations which may be used in the Specifications and the Commissioning Plan.

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SBN Far Detector Building

COMMISSIONING

2 MARCH 2015

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ISSUED FOR 90% REVIEW
1.3 COMMISSIONING PROCESS

A. Commissioning Plan. The commissioning plan (Cx Plan), which is in the appendix to this specification, provides definition for the execution of the commissioning process. The Commissioning Authority (CxA) shall update the Cx Plan throughout the course of the Cx Process.

B. Commissioning Process. For an overview of the typical commissioning tasks during construction and the general order in which they occur, refer to the Cx Plan.

1.4 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. All of the following sections apply to the Work of this section.

1. Commissioning Plan (Cx Plan)
2. Section 15995 - Commissioning of Mechanical
3. Section 16995 - Commissioning of Electrical

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. All standard testing equipment required to perform startup, initial checkout, and functional performance testing shall be provided by the Division Contractor. If required, two-way radios, ladders and/or man-lifts shall be provided by the General Contractor or applicable Subcontractor.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the related specifications. All equipment shall be calibrated according to the manufacturer’s recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

A. Refer to the Cx Plan in the appendix of this specification section.

END OF SECTION 01810
SECTION 02070
SELECTIVE DEMOLITION

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Provide labor, material and equipment to complete all demolition and removal as shown and as required to satisfy the condition of new construction.

B. Extent of Selective Demolition/Removal and disposal of demolished materials is shown on drawings and specified herein.

C. Subcontractor shall carefully examine drawings and specifications to determine extent of demolition, removal, patching and replacement work. Subcontractor shall be responsible for cutting, demolition, and removal of existing equipment and materials pertaining to his contract as specified and as required, whether specifically shown on drawings or not, to prepare for new work described. Subcontractor shall be responsible for patching, repair and replacement of work that is demolished, removed, cut or in any way altered by them.

D. Extent of removal is shown on the drawings and specified herein and includes, but is not necessarily limited to the following:

1. Pavement removal.
2. Miscellaneous structural mechanical and electrical items removal and/or relocation.

1.02 EXISTING CONDITIONS

A. Subcontractor shall carefully examine these documents and conditions at site to determine extent of removal required. Work remaining in place which is altered, damaged or defaced by reason of work done under this contract, shall be restored or repaired completely to original conditions or as shown or specified for adjoining work at no cost to Fermilab. If removal of existing work exposes deteriorated surfaces, or work out of alignment, such surfaces shall be repaired or the materials shall be replaced as necessary to make contiguous work uniform and harmonious and provide proper substrate.

B. Where new work connects with existing work, Subcontractor shall do all necessary cutting and fitting, and shall remove all existing work called for by drawings or specifications, and as required to make satisfactory connections with work in a finished, weathertight and workmanlike condition. Furnish all labor, material and equipment to the furtherance of this end whether or not they are distinctly shown or specified.
1.03 OCCUPANCY/SEQUENCING/SCHEDULE

A. Existing shafts and tunnels will be occupied by Fermilab during entire period of this new work.

B. Access to the existing Minos Building shall be maintained at all times.

1.04 JOB CONDITIONS

A. Traffic: Conduct demolition operations and removal of debris to ensure minimum interference with roads, streets, parking, walks and other occupied or used facilities.

B. Protections:
   1. Provide protected passageways to ensure safe passage of persons around the area of demolition. Conduct operations to prevent damage by falling debris or other cause to adjacent construction and other facilities, as well as persons.
   2. Provide shoring, bracing or support to prevent movement or settlement or damage to structures as a result of demolition work.
   3. Construct barricades, chutes and dust enclosures as necessary to protect the existing construction to remain.
   4. Observe all necessary safety procedures in carrying out this portion of the contract.

C. Utility Services:
   1. Maintain existing utilities; keep in service and protect against damage during demolition operations.
   2. Do not interrupt existing utilities serving occupied or used facilities, except when authorized in writing by authorities having jurisdiction. Provide temporary services during interruptions to existing utilities, as acceptable to Fermilab.
   3. Should uncharted or incorrectly charted piping or other utilities be encountered during demolition, consult Construction Coordinator immediately for directions as to procedure. Repair damaged utilities to satisfaction of utility company and Fermilab.

PART 2 PRODUCTS

Not Applicable
PART 3 EXECUTION

3.01 POLLUTION CONTROLS

A. Use water sprinkling, temporary enclosures and other suitable methods as necessary to limit amount of dust and dirt rising and scattering in air, to lowest level of air pollution practical for condition of work. Comply with governing regulations.

B. Clean adjacent areas of dust, dirt and debris caused by demolition operations. Return areas to condition existing prior to start of work.

3.02 DISPOSAL OF DEMOLISHED AND REMOVED MATERIALS

A. Remove from site all debris, rubbish and other materials resulting from demolition operations and dispose of off the site. Subcontractor's storage or sale of removed materials will not be permitted on site.

B. Burning of removed materials from demolition work will not be permitted on site.

C. Designated salvageable material and equipment shall be removed and maintained in as good condition as possible and turned over to Fermilab. However, if Fermilab decides any such materials are of no value to them then they shall become the property of the Subcontractor who shall remove such discarded work from the premises and dispose of same.

END OF SECTION 02070
SECTION 02100
SITE PREPARATION

PART 1. GENERAL

1.01 SECTION INCLUDES

A. Included in this section is all labor, materials, equipment, transportation, and supervision for general site preparation and grading work including, but not necessarily limited to, the following:

1. Survey, layout, lines and grades.
2. Clearing and grubbing.
4. Erosion Control.
5. Temporary site maintenance, drainage, and safety.
6. Temporary site protection, fencing, barricades and warning signals.
7. Permanent seeding of all disturbed areas.

1.02 RELATED WORK

A. Section 02220 – Excavating for Structures and Pavements
B. Section 02221 – Backfilling and Compacting for Structures and Pavements
C. Section 02222 – Excavating, Backfilling and Compacting for Utilities
D. Section 02500 – Roadways

1.03 REFERENCE TO STANDARDS

A. American Association of State Highway and Transportation Officials (AASHTO)
B. American Society for Testing and Materials (ASTM)
C. IEPA, Illinois Urban Manual (IUM)

1.04 SUBMITTALS

A. Certifications of permanent seed materials.
B. Written 1 year warranty on all newly established vegetation.

C. List of all manufactured items and materials proposed for installation on the project.

PART 2. PRODUCTS OR MATERIALS

2.01 MATERIAL STORAGE AREA

A. The material storage for which the Subcontractor may store all materials for this project will be shown on drawings.

B. The subcontractor shall be responsible for loading and transporting all materials from the designated storage area.

2.02 SUPPLIED FILL MATERIALS

A. Fill materials supplied and/or manufactured under this Section shall only be from IDOT approved sources.

2.03 TOPSOIL

A. Natural, friable, fertile, fine, loamy soil containing no less than 1.5 percent organic materials when tested per AASHTO T194, and generally representative of agriculturally productive soil in the vicinity of the jobsite. Topsoil shall be free from subsoil and objectionable material that would hinder plant growth or maintenance and shall not contain more than 5 percent by volume of stones, stumps, or other objects larger than 1 inch in any dimension.

2.04 SUITABLE FILL MATERIAL

A. Excavated or imported inorganic material cohesive and cohesionless materials including gravel, sand, inorganic lean clay, inorganic silt, gravel silt, gravel clay, sand clay, sand silt, or silt clay material free from frozen lumps, refuse, stones or rocks larger than 3 inches in any dimension or other material that may make the inorganic material unsuitable for backfill or fill material as determined by Fermilab's geotechnical engineer.

a. Cohesive Materials: Soils classified as GC, SC, ML, CL, MH, CH, or materials classified as GM or SM when their fine function (material passing a No. 40 sieve) has a plasticity index of 4 or greater.

b. Cohesionless Materials: Soils classified as GW, GP, SW, SP, and material classified as GM or SM when their fine function (material passing a No. 40 sieve) is nonplastic or has a plasticity index less than 4.

c. Gravel-Silt, Gravel-Clay, Sand-Silt, Sand-Clay Mixture containing 5 to 12 percent fines (e.g., GS-CL, SP-ML) is also suitable material.

2.05 SELECT STRUCTURAL BACKFILL MATERIAL
A. Granular backfill material shall be crushed gravel, class C or better, gradation CA-6 per IDOT Standard Specifications for use around structures where select structural backfill materials are required.

2.06 FREE DRAINING GRANULAR BACKFILL

A. Imported gravel or stone material meeting the gradation requirements of IDOT CA 7 or CA 11.

2.07 GRANULAR BEDDING AND TRENCH BACKFILL MATERIALS

A. Well-graded sand (SW or SW-SM), gravel (GW or GW-GM), meeting the gradation requirements of IDOT FA 1, FA 2, or FA 6.

2.08 GENERAL YARD SURFACING GRAVEL

A. Gravel shall meet the IDOT Standard Specification requirements as crushed gravel, class C or better, gradation CA-6, CA-7 or CA-11.

2.09 UNSUITABLE FILL MATERIAL

A. Material containing refuse, frozen lumps, demolished bituminous material, vegetative matter, wood, stones in excess of 3 inches in any dimension, and debris as determined by Fermilab's geotechnical engineer. Typically these will be soils classified as Pt, OH, and OL.

2.10 BORROW MATERIALS

A. Materials shall meet the requirements specified herein for suitable or select fill material.

PART 3. EXECUTION

3.01 PREPARATION

A. Before starting work, thoroughly examine the site to ascertain conditions under which the work must be performed.

3.02 SURVEY, LAYOUT, LINES, AND GRADES

A. Perform all survey, layout, staking, and marking to establish and maintain all lines, grades, elevations and benchmarks needed for execution of the work shown on the drawings.

B. Relate survey layout to the coordinate grid system, elevation datum, and related survey control points and benchmarks established by Fermilab.

C. The above survey and related work shall be performed in a timely manner relative to the other work of the Subcontract.

D. Inform the Fermilab Construction Coordinator immediately of any inconsistencies.
E. Maintain all field markings until all related work has been completed, inspected, and approved.

3.03 EROSION CONTROL

A. To the maximum extent practicable, the work shall be excavated, graded and stabilized in stages so that unprotected, denuded areas are minimized.

3.04 FENCING, BARRICADES AND WARNING SIGNALS

A. Provide and maintain temporary fencing, barricades, warning signals and similar devices necessary to protect life and property during the entire period of construction. Remove all such devices upon completion of the work.

3.05 CLEARING

A. The Subcontractor shall remove all trees, bush, etc. from the construction site, and access right-of-way. No attempt has been made to show all trees on the plans; however, tree removal is to be kept to a minimum. Fermilab shall move all trees within the construction limits prior to construction.

B. The Subcontractor shall examine the site to determine the extent of clearing work required.

3.06 GRUBBING

A. All stumps of trees and brush removed shall be grubbed to at least 2 feet below existing grade. This includes stumps that remain as a result of previous work in this area.

B. Areas that will not be further disturbed on this project shall be restored to grade with stripped material from the site.

3.07 STRIPPING TOPSOIL

A. Stripping of the vegetation and topsoil is required. Topsoil shall be removed from all building and pavement areas a minimum of 5 feet in all directions beyond the limits of the structure and pavement. Any area used as a source of fill should also be stripped of topsoil. Stripping depth shall be a minimum of 6”. The Subcontractor shall stockpile topsoil and finish grade material at the site to be used when the site construction is complete.

3.08 BURNING

A. Burning of trees and brush will not be allowed.

3.09 FINISH GRADING

A. Perform all finished grading to provide smooth, even surface drainage of the entire area within the limits of construction. Grading shall be compatible with all-surrounding topography and structures. The degree of finish for graded slopes shall that which
can be obtained by the use of suitable mechanical equipment, with only such hand labor as special conditions may require.

B. Utilize satisfactory fill materials resulting from the excavation work in the construction of fills, embankments and for the replacement of removed unsuitable materials.

C. All areas shall be finish graded with a minimum of six (6) inches of topsoil to the grades and elevations shown on the drawings.

3.10 FINISH SEEDING

A. Any disturbed areas shall be finish graded and seeded with the appropriate seed mixture.

a. SLOPE MIX:
   SLOPES GREATER THAN 3-1
   Annual Ryegrass 30%
   (Lolium multiflorum)
   Red Top 10%
   (Agrostis alba)
   Kentucky Blue Grass 98/85 25%
   (Poa Pratensis)
   Hungarian Brome 10%
   (Bromus inermus)
   *Little Blue Stem 15%
   (Schizachyrium scoporium)
   *Side Oats Grama 10%
   (Bouteloua curtipendula)

   Application Rate: 2 lbs. Per 1000 sq. ft.

b. MESIC LAND MANAGEMENT OR ROADSIDE MIX:
   SLOPES LESS THAN 3-1
   Annual Ryegrass 30%
   (Lolium multiflorum)
   Red Top 20%
   (Lolium perenne)
   Kentucky Blue Grass 98/85 25%
   (Poa Pratensis)
   *Little Blue Stem 15%
   (Schizachyrium scoporium)
   *Side Oats Grama 5%
   Bouteloua curtipendula
   *Canada Wild Rye 5%
   (Elymus canadensis)

   Application Rate: 2 lbs. Per 1000 sq. ft.

* Native seed in above mixes shall be of local ecotype genetics. (within 100 miles of Fermilab Site)
c. **TURF (GENERAL MIX):**
   - Kentucky Blue Grass 98/85 50%
   - Creeping Red Fescue 25%
   - Perennial Rye 25%

   Application Rate: 4 lbs. Per 1000 sq. ft.

B. Seed preparation, seed bed preparation, fertilizer, rolling, and seeding methods shall be in accordance with Section 250 of the IDOT Standard Specification. No seeds shall be sown during high winds or when the seedbed is not in a proper condition for seeding, nor shall any seed be sown until purity tests have been completed and accepted.

C. Seeding shall be restricted to May 15 through June 30 or September 15 to December 1. Temporary ground cover shall be for erosion control until the permanent seeding can be completed.

3.11 MULCHING

A. Provide mulching or other cover as necessary to insure germination and growth of seed. Subcontractor shall be required to provide Fermilab a written 1-year warranty on all newly established vegetation. Warranty shall include reseeding, mulching, grading, or any other actions necessary to establish required vegetative cover.

END OF SECTION 02100
PART 1     GENERAL

1.01 SECTION INCLUDES

A. Excavation, stripping and stockpiling of existing earth materials and dewatering of excavations as required under the project.

1.02 REFERENCE TO STANDARDS

A. American Society for Testing and Materials (ASTM):


C. Occupational Safety and Health Administration (OSHA): Current OSHA Occupational Safety and Health Standards - Excavations, 29 CFR Part 1926, including any successor regulations.

1.03 REGULATORY REQUIREMENTS

A. Codes and Standards

1. Perform excavation work in compliance with applicable requirements of governing authorities having jurisdiction.

2. Prior to the commencement of construction, the Subcontractor shall be aware of, and become familiar with applicable local, state and federal safety regulations, including the current OSHA Occupational Safety and Health Standards - Excavations, 29 CFR Part 1926, including any successor regulations.

3. Additionally, the Subcontractor shall be aware that slope height, slope inclination and excavation depths (including utility trench excavations) should in no case exceed those specified in local, state or federal safety regulations.
1.04 COORDINATION

A. Do not interrupt existing utilities serving facilities occupied and used by Fermilab or others except when permitted in writing by Fermilab and then only after acceptable temporary utility services have been provided. Provide minimum of 48 hour notice prior to enacting an approved temporary interruption.

1.05 SUBMITTALS

A. Subcontractor shall submit excavation plan for enclosure structure. Excavation plan shall be designed and approved by licensed Structural Engineer in Illinois.

PART 2 PRODUCTS (RESERVED)

PART 3 EXECUTION

3.01 EXAMINATION

A. Site Information

1. Data on indicated subsurface conditions are not intended as representations or warranties of accuracy or continuity between soil borings. It is expressly understood that Fermilab will not be responsible for interpretations or conclusions drawn therefrom by Subcontractor. Data are made available for convenience of Subcontractor.

2. Subcontractor shall be responsible for determining the actual ground water elevation and soil conditions at the specific site prior to commencing with the excavation. It may be expedient to drill auger holes, excavate test pits or make additional soil borings at or adjacent to the construction area immediately prior to construction to determine the prevailing soil conditions and water table elevation. It is the Subcontractor's responsibility to make auger holes, excavate test pits or make additional soil borings as he deems appropriate to determine the ground water and soil conditions that will be encountered. Additional test borings and other exploratory operations made by the Subcontractor shall be at no cost to Fermilab.

3.02 PREPARATION

A. Establish extent of excavated areas.

B. Set specified lines and levels.

C. Maintain benchmark, monuments and other reference points.
D. Before starting excavation, establish location and extent of underground utilities occurring in work area.

E. Maintain, reroute or extend existing utility lines to remain which pass through work area.

3.03 EXCAVATION

A. General

1. Excavation consists of removal and redistribution of material encountered when establishing required grade and subgrade elevations and cross sections.

2. The Subcontractor is solely responsible for designing and constructing stable excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. All excavations shall comply with applicable local, state and federal safety regulations including the current OSHA Occupational Safety and Health Standards - Excavations, 29 CFR Part 1926, including any successor regulations.

3. All sheeting, shoring and bracing of trenches, pits and excavations shall be the sole responsibility of the Subcontractor.

4. Construction site safety is the sole responsibility of the Subcontractor, including but not limited to, the means, methods, and sequencing of construction operations.

5. Earth excavation consists of removal and disposal of pavements and other obstructions visible on ground surface, underground structures and utilities indicated to be demolished and removed, material of any classification indicated in data on sub-surface conditions, and other materials encountered that are not classified as unauthorized excavation. Unsuitable material shall be hauled off site.

B. Unauthorized Excavation

1. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of the Construction Coordinator. Unauthorized excavation, as well as remedial work directed by Construction Coordinator, shall be at Subcontractor's expense. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing
or base to excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position, only when acceptable to Construction Coordinator. Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations of the same classification, unless otherwise directed by Construction Coordinator.

C. Additional Excavation

1. When excavation has reached required sub-grade elevations, notify Construction Coordinator who will make an inspection of conditions. If unsuitable bearing materials are encountered at required sub-grade elevations, carry excavations deeper and replace excavated material as directed by Construction Coordinator. Removal of unsuitable material and its replacement as directed will be paid on basis as directed by Fermilab.

D. Dewatering

1. Prevent surface water and subsurface or ground water from flowing into excavation and from flooding project site and surrounding area.

2. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

3. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey rain water and water removed from excavations to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

4. Pump changes shall conform to the requirements of the project storm water plan.

E. Material Storage

1. Stockpile satisfactory excavated materials in the location designated by the Construction Coordinator, until required for backfill or fill. Place, grade and shape stockpiles for proper drainage. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain. Contain excavated silt/soil runoff with hay bales and silt fences as directed by the Construction Coordinator and in accordance with Local, State and Federal Requirements. Hay bales and silt fences shall extend a
minimum of one foot below grade. Excavated materials will be stockpiled within one mile of the project site. Topsoil shall be segregated from clay materials.

F. Excavation for Structure

1. Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 feet, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, other construction and for inspection.

2. In excavating for footings and foundations, take care not to disturb bottom of excavation. Excavate by hand or smooth bladed backhoe to final grade just before underslab aggregate base is placed. Trim bottoms to required lines and grades to leave solid base to receive other work. After completion of excavation and prior to placement of concrete for footings, excavations shall be inspected and approved by the Construction Coordinator to insure that suitable bearing has been obtained. Twenty-four (24) hours notice shall be given to Construction Coordinator.

3. Placing of footings and foundations on earth fill will not be permitted. Fill excess cuts under footings and foundations with a minimum of twelve (12) inches of IDOT CA-6 Class C quality or better compacted to 98% Standard Proctor density in accordance with ASTM D698 and fill any excess cuts under slabs with compacted sand.

G. Excavation Near Utilities

1. Protect, support, shore, brace, etc. all utility services uncovered by excavation.

2. Accurately locate and record abandoned and active utility lines rerouted or extended, on Project Record Documents.

3. Repair damaged utilities to the satisfaction of the Utility Owner.

H. Disposal of Excess and Waste Materials

1. Removal from Fermilab’s Property

   a. Remove waste materials, trash, unsuitable materials and debris and legally dispose of it off Fermilab’s property.
2. Excess Material
   
a. Excess excavated material shall be transported and placed in locations on Ferminlab’s property as directed by Fermilab or Construction Coordinator.

3.04 FIELD QUALITY CONTROL

A. The Subcontractor shall allow bearing surfaces at the bottom of excavations to be inspected by the Construction Coordinator, and shall modify the bearing surfaces as requested by the Construction Coordinator, prior to placement of any base materials.

3.05 PROTECTION

A. Stability of Excavation
   
1. Slope sides of excavations to comply with local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible either because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in a safe condition until completion of backfilling.


B. Cold Weather Protection
   
1. Protect excavation bottoms against freezing when atmospheric temperature is less than 35°F (1°C).

C. Protection of Persons and Property
   
1. Fence and barricade open excavations occurring as part of this work and post with warning lights. Operate warning lights during hours from dusk to dawn each day and as otherwise required by authorities having jurisdiction.

2. Protect structures, landscaping, utilities, sidewalks, pavements or other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.


END OF SECTION 02220
SECTION 02221
BACKFILLING AND COMPACTING FOR STRUCTURES AND PAVEMENTS

PART 1    GENERAL

1.01   SECTION INCLUDES

A. Filling, backfilling and compaction below existing ground elevation 750.0.
B. Rough grading.
C. Preparation of subgrade for slabs and installation of footings.

1.02   RELATED SECTIONS (RESERVED)

1.03   REFERENCE TO STANDARDS

A. ASTM D698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).
B. ASTM D4253 - Maximum Index Density and Unit Weights of Soils Using a Vibratory Table.

1.04   SUBMITTALS

A. Submit under the provisions of Exhibit A, Section 12.0 - Submittals, Shop Drawings and Material Samples.
B. Submit copies of Standard Proctor Density Test results to Construction Coordinator a minimum of seven business days prior to backfilling any excavations.

1.05   QUALITY ASSURANCE

A. Compaction Testing

1. Standard Proctor Density Testing and Compaction Testing of fill materials and inspection of subgrades and fill layers will be performed by the Subcontractor’s testing service, using Proctor information furnished by the Subcontractor.

2. If in the opinion of Construction Coordinator, based on testing service reports and inspection, subgrade or fills which have been placed are below
specified density, provide additional compaction and testing at no additional expense to Fermilab.

3. When, during progress of work, tests indicate that compacted materials will not meet specifications, remove defective work, replace and retest at no additional cost to Fermilab.

4. Ensure that all compacted fills are tested before proceeding with placement of surface materials.

PART 2 PRODUCTS

2.01 DEFINITIONS

A. Suitable Soil

1. Suitable soil is a soil having less than 5% organic matter by weight as determined by the Loss on Ignition Test (determine weight loss caused by heating sample to 500°F for 6 hours after drying in accordance with ASTM D-2216, "Laboratory Determination of Moisture Content of Soil").

B. Unsuitable Soil

1. Unsuitable soil is a soil that contains 5% or more organic matter as determined by the Loss of Ignition Test previously specified, rubbish, vegetable matter of every kind, roots, and boulders larger than 5 inches in dimension which might interfere with the proper bonding to adjacent contact surfaces, or as otherwise determined unsuitable by the Construction Coordinator.

C. Cohesive Soil

1. Cohesive soil is a soil containing more than 50 percent fine material passing the No. 200 standard sieve, and with more than 15 percent clay-size particles smaller than 0.002 mm (2 microns). The soil matrix passing the No. 40 standard sieve exhibits dry (crushing) strength in the dry state and cohesive shear strength in the moist state, as well as being plastic in the moist state.

2.02 BACKFILL MATERIALS

A. Base Materials

1. Where indicated on drawings, IDOT CA-6 crushed limestone Class C Quality, minimum of 12 inches in depth unless otherwise shown.
B. Fill and Base Materials - Parking Area

1. Granular fill or base materials below the proposed parking will be IDOT CA-6 crushed limestone Class C Quality.

C. Finish Grading

1. See Section 02230 - Embankment for more information.

2.03 FILTER FABRIC

A. Nonwoven needle punched geotextile composed of polypropylene filaments formed into a stable network. Filter fabric shall be inert to biological degradation and to naturally encountered chemicals, alkalines and acids.

B. Filter fabric shall be Mirafi 140N or an equal material conforming to the properties listed below:

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<th>PROPERTY</th>
<th>TEST METHOD</th>
<th>UNIT</th>
<th>MINIMUM</th>
<th>AVERAGE</th>
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<td>Thickness</td>
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C. Filter fabric shall be shipped in roll sizes to minimize the number of laps required during installation.

PART 3  EXECUTION

3.01 EXAMINATION

A. Prior to placement of any fill or backfill and prior to placement of all subsequent fill lifts, Subcontractor shall contact an independent testing laboratory for inspection and testing of excavation subgrade and testing of each compacted layer of fill and backfill material. The Subcontractor shall make arrangements with an independent laboratory for inspection and testing of excavation subgrade and testing for each
compacted layer of fill and backfill material and shall pay for those tests. Name of testing firm chosen by Subcontractor shall be submitted to the Construction Coordinator for approval prior to beginning compaction work. The Subcontractor shall provide Proctor information necessary to perform density testing on in-place backfill material.

3.02 PREPARATION

A. Backfilling and compaction shall not occur until the following conditions are satisfied:
   1. Acceptance by Construction Coordinator of construction below finish grade including, where applicable, dampproofing and perimeter insulation.
   2. Inspection, testing, approval and recording locations of underground utilities.
   4. Removal of trash and debris, vegetation, snow or ice, water, unsatisfactory soil materials, obstructions and deleterious materials.
   5. Removal of shoring and bracing and backfilling of voids with satisfactory material.
   6. Ensure that ground surface within excavated area to be backfilled is not frozen.
   7. When existing ground surface has a density less than that specified under Article 3.03-C of this Section for particular area classification, break up ground surface, pulverize, moisture-condition to optimum moisture content and compact to required depth and percentage of maximum density.

3.03 BACKFILLING AND COMPACTING

A. General
   1. Place acceptable soil material in layers to required subgrade elevations, for each area classification listed below.
      a. In existing lawn areas, use satisfactory excavated or borrow exterior fill material.
      b. Building related, use base material as indicated.

B. Placement and Compaction
1. Place backfill, base and fill materials in layers not more than 8 to 12 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches in loose depth for material compacted by hand aerated tampers. Heavy equipment including compaction equipment shall not operate within 2 feet of unbraced substructure walls. Compaction in these areas shall be obtained with hand operated compaction equipment or devices. Earth backfill and native soil backfill shall be compacted with sheepfoot compaction equipment.

2. Before compaction, moisten or aerate each layer as necessary to provide the optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification. Do not place backfill or fill material on surfaces that are muddy, frozen or contain frost or ice.

3. Place backfill and fill materials evenly adjacent to structure to required elevations. Take necessary precautions to prevent wedging action of backfill against structures by carrying the material uniformly around structure to approximately same elevation in each lift.

C. Percentage of Maximum Density Requirements

1. Unless otherwise noted on the plan sheets, the Subcontractor shall compact each layer of soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture density relationship (cohesive soils) determined in accordance with ASTM D698, Standard Proctor Compaction Test; and not less than the following percentages of relative density, determined in accordance with ASTM D4253, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).

   a. Base Materials for Other Footings and Slabs

      1. Compact top 12 inches of subgrade and each layer of backfill or fill material to 98% of the Standard Proctor density for cohesive material or to 98% relative density for cohesionless soils.

   b. Paved Areas

      1. Compact top 12 inches of subgrade and each layer of backfill or fill material to 95% of the Standard Proctor density for cohesive material or 90% of the relative density for cohesionless soils.

   c. Lawn or Unpaved Areas
1. Compact top 6 inches of subgrade and each layer of backfill or fill material to 90% relative density for cohesionless soils and to 95% Standard Proctor density for cohesive soil materials.

D. Moisture Control

1. Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water top surface or subgrade or layer of soil material, to prevent free water appearing on surface during or subsequent to compaction operations. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.

E. Grading

1. General

a. Uniformly grade areas within limits of excavation under this Section, including adjacent transition areas. Compact with uniform levels or slopes between such points and existing grades.

b. Remove stones over 1-1/2" in any dimension and sticks, roots, rubbish and other extraneous matter.

c. Rough grade to 6" - 12" below finish, grades and elevations indicated in the drawings.

d. Grading Outside Structure Lines

1. Grade areas adjacent to building lines to drain away from structures and to prevent ponding.

2. Finish surfaces free from irregular surface changes, and as follows:

   a. Slabs: Shape surface of areas under slabs to line, grade and cross-section, with finish surface not more than 1/2" above or below required subgrade elevation.

2. Compaction

   a. After grading, compact subgrade surfaces to the depth and percentage of maximum or relative density for each area classification.
F. Maintenance

1. Protection of Graded Areas
   a. Protect newly graded areas from traffic and erosion. Keep free of
      trash and debris.
   b. Repair and re-establish grades in settled, eroded, and rutted areas
      to specified tolerances.

2. Reconditioning Compacted Areas
   a. Where completed compacted areas are disturbed by subsequent
      construction operations or adverse weather, scarify surface,
      reshape and compact to required density prior to further
      construction.

3. Settling
   a. Where settling is measurable or observable at excavated areas
      during general project warranty period, remove surface (pavement,
      lawn or other finish), add backfill material, compact, and replace
      surface treatment. Restore appearance, quality and condition of
      surface or finish to match adjacent work and eliminate evidence of
      restoration to greatest extent possible.

3.04 FILTER FABRIC INSTALLATION

A. Prepare subgrade as recommended by the filter fabric manufacturer prior to
   installation.

B. Install filter fabric as shown on the drawings and in accordance with manufacturer's
   installation procedures, including lap splice and anchorage requirements.
   Minimum lap splice of filter fabric shall be 2'-0".

3.05 FIELD QUALITY CONTROL

A. Quality Control Testing During Construction
   1. Allow the Construction Coordinator to inspect subgrades and fill layers
      before further construction work is performed.
   2. If in opinion of Construction Coordinator, based on field density testing and
      inspection, subgrade or fills which have been placed are below specified
      density, provide additional compaction and testing at no additional expense
      to Fermilab.
END OF SECTION 02221
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SECTION 02222

EXCAVATING, BACKFILLING AND COMPACTING FOR UTILITIES

PART 1  GENERAL

1.01  WORK INCLUDES

A.  Base Bid

1.  General Sub-Contractor to provide:
   a.  Excavate trenches for domestic water, industrial cooling water, storm sewer, and gas lines to public utility mains.
   b.  Compacted bed and compacted fill over plumbing lines.
   c.  Compaction.
   d.  Provide coordination of compaction inspection and testing services.

2.  Electrical Sub-Contractor to provide:
   a.  Excavate trench for electrical and communication service lines and electrical distribution lines to public utility lines and between service buildings and enclosures.
   b.  Compacted bed and compacted fill over electrical lines.
   c.  Compaction.
   d.  Provide coordination of compaction inspection and testing services.

1.02  RELATED WORK

A.  Specified elsewhere:

1.  All Sections of Division 2.
2.  Applicable information in Sections of Division 15 and 16.

1.03  COMPACTION TESTING

A.  Tests and analysis of fill materials shall be performed in accord with ANSI/ASTM D698.

B.  Testing of compacted fill materials at trenches shall be performed by the Owner's independent testing laboratory employed and paid for by the Owner. Testing shall be coordinated by the Subcontractor and performed in a manner to least encumber performance of work.

C.  Plumbing and Electrical Subcontractors shall pay for all additional tests for their respective portions of the work when initial tests show nonconforming work.

D.  When, during progress of work, tests indicate that compacted materials do not meet specifications, remove defective work, replace and retest, as directed in writing by Architect/Engineer.
E. Ensure that all compacted fills are tested before proceeding with placement of surface materials.

F. Tests and analysis of materials shall be performed in accord with Section 01410.

1.04 REFERENCES. Specified references, or cited portions thereof, current at date of bidding documents unless otherwise noted, govern the work.

   3. D1556 - Density of Soil In Place by Sand-Cone Method.


1.05 SUBMITTALS

A. Subcontractors:
   1. Submit samples in accord with Section 01410.
   2. Submit material certifications for backfill materials.
   3. Submit five (5) copies of all inspection and test reports on compaction at utility trenches to Construction Manager.

B. Construction Manager:
   1. Submit copies of all inspection and testing reports of utility trenches to Femilab Construction Coordinator.

1.06 PROTECTION

A. Protect excavations by shoring, bracing, sheet piling, underpinning or other methods to 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 Fermilab Construction Coordinator immediately of unexpected subsurface conditions. Confirm notification in writing. Discontinue work until Fermilab Construction Coordinator issues written notification to resume work.

D. Protect bottom of excavations and soil adjacent to and beneath foundations from frost.

E. Grade excavation top perimeter to prevent surface water runoff into excavation.

PART 2 PRODUCTS

2.01 SELECT BED AND FILL MATERIALS

A. Type A: Coarse Stone or Grave: Pit run, angular, crushed, washed natural stone; free of shale, clay, friable materials and debris; graded in accord with ANSI/ASTM C136 within the following limits:

<table>
<thead>
<tr>
<th>SIEVE SIZE</th>
<th>% PASSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4 in.</td>
<td>95 to 100</td>
</tr>
</tbody>
</table>

B. Type B: Pea Gravel: Natural stone, washed; free of clay, shale organic matter; 1/4 inch minimum to 5/8 inch maximum size; graded in accord with ANSI/ASTM C136-81.

C. Type C: Sand: Clean natural river or bank sand; washed; free of silt, clay, loam, friable or soluble materials and organic matter; graded with ANSI/ASTM C136-81 within the following limits:

<table>
<thead>
<tr>
<th>SIEVE SIZE</th>
<th>% PASSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 50</td>
<td>5 to 90</td>
</tr>
</tbody>
</table>

D. Type D: Building interior floor slab base material: IDOT gradation CA-6, class C quality or better.

2.02 COMMON FILL MATERIALS

A. Subsoil: Reused or Imported; free of gravel larger than three (3) inch size, and debris.

2.02 ACCESSORIES

A. Geotextile fabric as shown in the typical pavement details.

PART 3 EXECUTION

3.01 INSPECTION

A. Verify stockpiled fill to be reused is approved in writing by Architect/Engineer.
NOTE: Spoil materials from trenches within in the building limits will be wasted outside of the building.

B. Verify buried utility or pipe installation has been inspected and approved in writing by Architect/Engineer prior to backfilling.

C. 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. Excavate subsoil: For piping or conduit to utility lines:

1. Plumbing Subcontractor for:
   a. Water lines.
   b. Gas lines.
   c. Condensate drain lines.
   d. Storm sewer lines.

2. Electrical Subcontractor for:
   a. Electrical and communication service and distribution lines.

B. Cut trenches wide enough to enable utility installation and allow inspection.

C. Hand trim excavation and leave free of loose matter. Hand trim for bell and spigot pipe joints.

D. Remove lumped subsoil, boulders and rock.

E. Excavation shall not interfere with normal 45 degree bearing splay of foundations.

F. Correct unauthorized excavation.

G. Fill over-excavated areas under pipe or conduit bearing surfaces in accord with Fermilab Construction Coordinator directions.

H. Stockpile excavated material in area designated on site and remove excess subsoil not being reused from site.

I. For trenches on the building interior, protect existing subgrade from contamination with trench spoil material. Waste spoil outside of building limits.

3.04 BACKFILLING
A. Support pipe and conduit 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 geotextile fabric at all trenches that occur under paved areas.

D. Place and compact select fill materials in continuous layers not exceeding 8 in. loose depth.

E. Place and compact common fill material in continuous layers not exceeding 12 in. loose depth.

F. Use a placement method that will not disturb or damage utilities in trenches.

G. Maintain optimum moisture content of backfill materials, determined by laboratory analysis, to obtain specified compaction density.

H. Remove surplus backfill materials from site.

I. Leave stockpile areas completely free of excess fill materials.

3.05 TOLERANCES. Top surface of backfilling: Plus or minus 1/2 in.

3.06 FILL TYPES AND COMPACTION. Compact all fill and backfill to specified values based on Standard Proctor Test.

A. Existing Ground In Place:

<table>
<thead>
<tr>
<th>Area/Condition</th>
<th>Percent of Compaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Overlot – landscaped areas</td>
<td>95%</td>
</tr>
<tr>
<td>2. Footings, foundations</td>
<td>98%</td>
</tr>
<tr>
<td>3. Pavements, floor slabs</td>
<td></td>
</tr>
<tr>
<td>a. 2 ft. or more below subgrade</td>
<td>98%</td>
</tr>
<tr>
<td>b. Less than 2 ft. below subgrade</td>
<td>98%</td>
</tr>
</tbody>
</table>

B. Backfill Materials:

<table>
<thead>
<tr>
<th>Area/Condition</th>
<th>Fill Type</th>
<th>Max. Lift</th>
<th>Percent of Compaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Trenches under floor slabs</td>
<td>D</td>
<td>8 in.</td>
<td>98%</td>
</tr>
<tr>
<td>a. Top 8 in. below slab</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. 8 in. and more below slab</td>
<td>C</td>
<td>8 in.</td>
<td>98%</td>
</tr>
<tr>
<td>2. Trenches under pavements, roads, parking lots, sidewalks</td>
<td>A</td>
<td>8 in.</td>
<td>98%</td>
</tr>
</tbody>
</table>
b. 8 in. and more below slab  D 8 in.  98%

3. Cross lot fill – landscaping  D 12 in.  95%

C. Moisture Content: Not less than 2% below optimum moisture content determined in accord with:


3.07 COMPACITION TESTING. Testing will be performed in accord with ANSI/ASTM D698.

3.08 SURPLUS MATERIALS

A. Remove surplus materials from site.

B. Leave stockpile areas completely free of all excess fill materials.

END OF SECTION 02222
SECTION 02230

EMBANKMENT

PART 1  GENERAL

1.01  SECTION INCLUDES

A. Construction of the embankment indicated in the drawings and around the SBN Far Detector structure. Construction of the embankment shall consist of depositing, placing and compacting, where indicated, earth, mine tailings or other materials of acceptable quality above the existing ground or roof structure of the Mini-BooNE Detector as shown on the drawings.

B. The work shall include transporting and spreading material, moisture control, compaction, fine grading and all other incidental work associated with the construction of the embankment.

C. Materials for embankment shall consist of excavated materials from the construction of the detector structure and mine tailings borrow material from another Fermilab project site and within one mile of the proposed Mini-BooNE Detector project site. Maintain segregation of topsoil, clay materials and mine tailings stockpiles.

1.02  RELATED SECTIONS (RESERVED)

1.03  REFERENCE TO STANDARDS

A. ASTM D698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³).

B. ASTM D4253 - Maximum Index Density and Unit Weights of Soils Using a Vibratory Table.


1.04  SUBMITTALS

A. Submit under the provisions of Exhibit A, Section 12.0 - Submittals, Shop Drawings and Material Samples.

B. Submit copies of Standard Proctor Density Test results to Construction Coordinator a minimum of seven business days prior to backfilling any excavations.
1.05 QUALITY ASSURANCE

A. Compaction Testing

1. Standard Proctor Density Testing and Compaction Testing of fill materials and inspection of subgrades and fill layers will be performed by the Subcontractor’s testing service, using Proctor information furnished by the Subcontractor.

2. If in the opinion of Construction Coordinator, based on testing service reports and inspection, embankment materials or fills which have been placed are below specified density, provide additional compaction and testing at no additional expense to Fermilab.

3. When, during progress of work, tests indicate that compacted materials will not meet specifications, remove defective work, replace and retest at no additional cost to Fermilab.

4. Ensure that all compacted embankment materials are tested before proceeding with placement of surface materials.

PART 2 PRODUCTS

2.01 EMBANKMENT MATERIALS

A. Existing excavated stiff silty and sandy clay materials from the construction of the SBN Far Detector structure will be acceptable as embankment material and is to be utilized where shown on the drawings.

PART 3 EXECUTION

3.01 EXAMINATION

A. The Subcontractor shall make arrangements with an independent laboratory for inspection and testing of each compacted layer of embankment and shall pay for those tests. Name of testing firm chosen by Subcontractor shall be submitted to the Construction Coordinator for approval prior to beginning compaction work. The Subcontractor shall provide Proctor information necessary to perform density testing on embankment material.

3.02 PREPARATION

A. Embankment placement and compaction shall not occur until the following conditions are satisfied:

1. Acceptance by Construction Coordinator of construction below finish grade including, where applicable, dampproofing.
2. Inspection, testing, approval and recording locations of underground utilities.
4. Removal of trash and debris, vegetation, snow or ice, water, unsatisfactory soil materials, obstructions and deleterious materials.
5. Removal of shoring and bracing and backfilling of voids with satisfactory material.
6. Ensure that ground surface within embankment area is not frozen.
7. When existing ground surface has a density less than that specified under Article 3.03-C of this Section for particular area classification, break up ground surface, pulverize, moisture-condition to optimum moisture content and compact to required depth and percentage of maximum density.

3.03 EMBANKMENT PLACEMENT AND COMPACTING

A. General

1. Place embankment material in layers to required subgrade elevations indicated on the drawings.

2. Disk each layer sufficiently to break down oversize clods to a maximum of 4 inches.

B. Placement and Compaction

1. Place embankment materials in layers not more than 8 to 12 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches in loose depth for material compacted by hand operated tampers. Heavy equipment including compaction equipment shall not operate within 2 feet of structure walls. Compaction in these areas shall be obtained with hand operated compaction equipment or devices. Embankment around the structure perimeter shall be compacted with sheepsfoot compaction equipment.

2. Placement of the clay fill materials on top of the Detector structure may be completed with the use of small tractors or rubber tired end loaders. After the placement of approximately 2 feet of embankment on the structure, the Subcontractor shall disk each successive layer and compact with a small pull-behind sheepsfoot roller and compact the fill to the degree possible utilizing the lighter weight equipment. The Subcontractor shall obtain approval from the Construction Coordinator for use of proposed equipment on the roof of the structure.

3. Before compaction, moisten or aerate each layer as necessary to provide the optimum moisture content. Compact each layer to required percentage
of maximum dry density or relative dry density for each area classification. Do not place embankment material on surfaces that are muddy, frozen or contain frost or ice.

4. Place embankment materials evenly adjacent to structure to required elevations. Take necessary precautions to prevent wedging action of embankment against structures by carrying the material uniformly around structure to approximately same elevation in each lift.

C. Percentage of Maximum Density Requirements

1. Unless otherwise noted on the plan sheets, the Subcontractor shall compact each layer of soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture density relationship (cohesive soils) determined in accordance with ASTM D698, Standard Proctor Compaction Test; and not less than the following percentages of relative density, determined in accordance with ASTM D4253, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).

   a. Embankment over the proposed structure.
      1. Loose lay material over proposed structure to elevations indicated on the drawings. Do not use heavy equipment for compaction in this area.

   b. Embankment around proposed structure.
      1. Compact top 6 inches of subgrade and each layer of embankment to 93% Standard Proctor Density.

D. Moisture Control

1. Where layer of soil material must be moisture conditioned before compaction, uniformly apply water to top surface or subgrade of soil material, to prevent free water from appearing on surface during or subsequent to compaction operations. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.

E. Grading

1. General
   a. Uniformly grade areas within limits of embankment under this Section, including adjacent transition areas. Compact with uniform levels or slopes between such points and existing grades.
b. Remove stones over 1-1/2" in any dimension and sticks, roots, rubbish and other extraneous matter.

c. Rough grade to 6" - 12" below finish, grades and elevations indicated in the drawings.

d. Grading Outside Structure Lines
   1. Grade areas adjacent to structure as indicated on the drawings.

2. Compaction
   a. After grading, compact subgrade surfaces to the depth and percentage of maximum or relative density for each area classification.

F. Maintenance

1. Protection of Graded Areas
   a. Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

   b. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.

2. Reconditioning Compacted Areas
   a. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape and compact to required density prior to further construction.

3. Settling
   a. Where settling is measurable or observable at embankment areas during general project warranty period, remove surface (lawn or other finish), add embankment material, compact, and replace surface treatment. Restore appearance, quality and condition of surface or finish to match adjacent work and eliminate evidence of restoration to greatest extent possible.

3.04 FIELD QUALITY CONTROL

A. Quality Control Testing During Construction

1. Allow the Construction Coordinator to inspect embankment before further construction work is performed.
2. If in opinion of Construction Coordinator, based on field density testing and inspection, embankment materials which have been placed are below specified density, provide additional compaction and testing at no additional expense to Fermilab.

END OF SECTION 02230
SECTION 02280
TEMPORARY UTILITY SUPPORT SYSTEMS

PART 1     GENERAL

1.01 RELATED DOCUMENTS
A. Examine all other portions of the Subcontract documents, including Exhibit A and Supplementary Terms and Conditions, for work related to the work of this Section. Provide all work hereunder as required for the support and accommodation of related work.

1.02 SCOPE
A. All labor, materials, equipment, transportation, supervision, and services necessary for the design and installation of the temporary utility support systems to the minimum limits shown on the drawings in the vicinity of existing roadways, buildings, tunnels and other facilities.

B. The Subcontractor must provide with his bid details of the construction method proposed to be used. In addition, the Subcontractor shall be responsible for the design of the entire utility support system. This design shall be submitted to Fermilab for review and approval as outlined in the submittals portion of the Exhibit A.

1.03 SECTION INCLUDES
A. Design of temporary utility support systems for the excavation for and construction of the SBN Far Detector Building in the vicinity of existing roadways, buildings, tunnels and other facilities.

1.04 RELATED SECTIONS
B. Section 02220    Excavating for Structures and Pavements
C. Section 02222    Excavating, Backfilling and Compacting for Utilities

1.05 RELATED WORK
A. Examine all other portions of the Subcontract documents for work related to this Section. Provide all work hereunder as required for the support and accommodation of related work.
1.06 CONDITIONS

A. The work of this Section is subject to the Fermilab Construction Subcontract Terms and Conditions and to Exhibit A, Schedule and Supplementary Terms and Conditions.

1.07 REFERENCE TO STANDARDS

A. Applicable Standards: The publications and references listed below form a part of this Section. Each publication shall be the latest revision and addendum in effect on the date of the Subcontract unless noted otherwise. Except as specifically modified by the requirements specified herein or the details of the drawings, the Work included under this Section shall conform to the provisions of these publications.

B. American Institute of Steel Construction (AISC):


C. American Society for Testing and Materials (ASTM):

1. ASTM A 36 “Specification for Structural Steel”.
2. ASTM A 325 “Specification for High Strength Bolts for Structural Steel Joints”.
3. ASTM A 501 “Specification or Hot-Formed Welded and Seamless Carbon Steel Structural Tubing”.
5. ASTM F 436 “Specification for Hardened Steel Washers”.

D. American Welding Society (AWS):

1. AWS D1.1 “Structural Welding Code”.

E. Occupational Safety and Health Administration (OSHA): Subcontractor shall note the OSHA requirements for excavations, particularly requirements set forth in Federal Register, Tuesday, October 31, 1989, 29CFR Part 1926 including any successor regulations. Compliance with this publication and any other OSHA excavation requirements in the Subcontractor’s responsibility only.

1.08 SUBMITTALS

A. Submittals: The following items shall be submitted to Fermilab for review and release. Review and release of submittals does not relieve the Subcontractor of any of the responsibilities and requirements of this Section and the design drawings. Fermilab’s review will be made to verify that the general scope of work is adequate, and that the Subcontractor is qualified to perform the work. Review of the Subcontractor’s plans and methods of construction shall not be construed to relieve the Subcontractor in any way of his responsibility for the successful performance of the work.
1. Working drawings, calculations, specifications and a design submission thoroughly describing the temporary utility support systems. Drawings shall include plans, elevations, connection details, and sections of the systems and a sufficient number of details to clearly illustrate the work. The submittal shall be prepared and sealed by a Licensed Structural Engineer registered in the State of Illinois.

2. Manufacturer’s Certificate of Compliance: Certification that products supplied meet or exceed specified requirement.

3. A list identifying the engineer and on-site supervisors whom will be assigned to the project. The list shall contain a summary of each individual's experience, and it shall be complete enough for Fermilab’s Construction Coordinator to determine whether or not each individual has satisfied the requirements of five years of related experience on similar projects.

1.09 EXISTING CONDITIONS

A. Existing site geotechnical conditions have been investigated. A copy of available geotechnical reports is available for review at Wilson Hall in the Fermilab Engineering Services Section (FESS) office at Fermilab. The information contained in the report shall not be construed as a guarantee of the depth, extent, or character of materials actually present.

B. Existing utilities other than those to be supported are located near the construction site. Care shall be taken not to damage those utilities or to disrupt service of same unless approved by the Fermilab Construction Coordinator. The Subcontractor shall be responsible for locating and protecting existing utilities.

C. The Subcontractor shall immediately notify the Fermilab Construction Coordinator if conditions vary from those indicated.

1.10 QUALITY ASSURANCE

A. The utility support systems shall be designed by a Licensed Structural Engineer registered in the State of Illinois and having a minimum of three years experience in similar construction.

1. Use of a consultant or manufacturer's representative will not meet the requirements for a staff Illinois Licensed Structural Engineer.

2. Inadequate proof of qualifications will not meet the requirements for a staff Illinois Licensed Structural Engineer.

3. Inadequate proof of the qualifications, as judged by Fermilab, shall be cause for rejection of the proposed utility support designer.

B. Fermilab reserves the right to suspend the work if the Subcontractor substitutes unqualified personnel for approved personnel during construction. If work is suspended due to the substitution of unqualified personnel, the Subcontractor shall
be fully liable for additional costs resulting from the suspension of work and no adjustment in contract time resulting from the suspension of work will be allowed.

1.11 DESIGN

A. The utility support systems shall be designed to safely support all loads as determined by the designer. Design calculations and drawings shall be sealed by a Licensed Structural Engineer registered in the State of Illinois.

B. The designer of the temporary utility support system shall visit the site prior to the design of the support system to determine the loadings required for the design based on the existing conditions of the utilities.

PART 2 PRODUCTS

2.01 MATERIALS

A. All structural steel plates, shapes, or bars shall conform to ASTM A36 (minimum).

B. Bolts shall conform to ASTM A325 with nuts conforming to ASTM A563.

C. Welding electrodes shall be low hydrogen E-70xx meeting the requirements of AWS D1.1 for the welding process employed.

2.02 PRODUCT DELIVERY, STORAGE, HANDLING

A. All materials shall be carefully handled during shipment and off-loading.

B. Store all materials on wood dunnage. Slope ground away from storage area.

C. All materials shall be clearly marked with the length, section number, and material specification number.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify site location and conditions prior to the execution of work.

B. Protect existing nearby structures from any possible damage that may result from the work that is to be performed.

3.02 INSTALLATION

A. Install utility support system in accordance with designer’s specific instructions.

END OF SECTION 02280.
SECTION 02311
ROUGH GRADING

PART 1. GENERAL

1.01 SECTION INCLUDES

A. Excavating topsoil and subsoil.
B. Cutting, filling, grading, and rough contouring the site for site structures and topsoil.

1.02 Related Sections

A. Section 02220 – Excavating for Structures and Pavements
B. Section 02221 – Backfilling and Compacting for Structures and Pavements
C. Section 02222 – Excavating, Backfilling and Compacting for Utilities
D. Section 02920 - Topsoil.

1.03 REFERENCES

A. ASTM International, (ASTM):
   2. ASTM D698 - Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. (12,400 ft-lbs/cu ft) (600 kN-m/cu m).
   3. ASTM D1557 - Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 ft-lbf/cu ft (2,700 kN-m/cu m)).
B. Illinois Department of Transportation (IDOT); Standard Specification for Road and Bridge Construction in Illinois, latest edition.
C. Occupational Safety and Health Administration (OSHA): Current OSHA Standards-Excavations, 29 CFR Part 1926, including any successor regulations.

PART 2. PRODUCTS

2.01 MATERIALS

A. Unless other materials are specifically indicated for backfilling and filling, use soil materials excavated from site.
B. Render all backfill and fill materials free of rock or gravel larger than 2” in any dimension, debris, waste, frozen parts, vegetation and other deleterious matter.

PART 3. EXECUTION

3.01 EXAMINATION

A. Verify site conditions under the direction of the Fermilab Construction Coordinator.

B. Verify that survey benchmark and intended elevations for the Work are as indicated.

3.02 PREPARATION

A. Notify affected utility companies before starting work and comply with their requirements.

B. Mark location of all existing utilities. Protect from damage utilities indicated to remain.

C. Protect plant life, lawns and other features remaining as a portion of final landscaping.

D. Protect benchmarks, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

3.03 SUBSOIL EXCAVATION

A. Excavate subsoil from areas to be further excavated, re-landscaped, or re-graded.

B. Do not excavate wet subsoil, or excavate and process wet material to obtain optimum moisture content.

C. When excavating through roots is necessary, perform work by hand and cut roots with sharp axe.

D. Benching Slopes: Horizontally bench existing slopes greater than [1:4] to key placed fill material to slope to provide firm bearing.

E. Stability: Replace damaged or displaced subsoil to same requirements as for specified fill.

3.04 FILLING

A. Cut and fill areas to contours and elevations with specified materials.

B. Place fill material in maximum 8” thick layers. Compact to minimum 95 percent of maximum standard Proctor density
C. Do not place fill materials on surfaces that are muddy, frozen, or contain frost or ice.

D. Maintain optimum moisture content of fill materials to attain required compaction density.

E. Remove rock or gravel larger than 2” in any dimension, debris, waste, obstructions, and deleterious matter from ground surface prior to placement of fills.

F. Slope grade away from buildings minimum 2” in 10’, unless noted otherwise.

G. Make grade changes gradual. Blend slope into level areas.

H. Repair or replace items indicated to remain damaged by excavation or filling.

3.05 TOLERANCES

A. Top Surface of Subgrade: Plus or minus 1/10’

3.06 FIELD QUALITY CONTROL

A. Testing: In accordance with ASTM D2922. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

B. Frequency of Tests: One test for every 5000 sq. ft of area for each layer (lift) with a minimum of 2 tests per layer of fill.

END OF SECTION 02311
SECTION 02370
EROSION CONTROL

PART 1. GENERAL

1.01 DESCRIPTION OF THE WORK

This work shall consist of constructing temporary and permanent erosion control systems, as shown on the plans or as ordered by the Construction Coordinator, during the life of the contract to control erosion and sediment damage to the adjacent properties and water resources through the use of temporary seeding, riprap, ditch checks, rock dams, erosion control fabric fence and inlet sedimentation control. The Subcontractor shall follow the provisions of the Illinois Urban Manual for general guidance when not specifically identified on the plans or in the specifications.

Any temporary erosion control methods ordered by the Construction Coordinator shall be coordinated with the permanent erosion control features specified elsewhere in the contract to the extent practical to assure economical, effective and continuous erosion control throughout the construction period.

At a minimum the sub-contractor shall place two runs of erosion control fabric fence between the work area and any stream, wetland or wetland buffer, floodplain, riparian area, drainage way, swale or pond. Additionally, the sub-contractor shall provide around all inlets, end sections and other drainage pipes an enclosure of suitable temporary erosion control measures to prevent clods of dirt, rock and other debris from entering into the drain ways near the construction activities.

Temporary construction access points shall be limited to areas established by the sub-contractor and approved by the Fermilab construction coordinator. These temporary access points shall be provided with temporary hardstand areas where extraneous materials can be removed from vehicles and equipment prior to entering onto the roadway system.

Where material is deposited onto the roadway system, the sub-contractor shall provide mechanical sweeping devices to remove the debris, siltation, dirt or rock no less than daily.

PART 2. MATERIALS

2.01 EROSION CONTROL FABRIC FENCE

This fence shall conform to the requirements specified herein. A 36" width of the filter fabric shall be secured to the bottom of the fence on its upstream side as shown in the plans.

Geotextile fabric for silt fence shall consist of woven or nonwoven filaments of polypropylene, polyester or polyethylene. Nonwoven fabric may be needle punched, heat-bonded, resin-bonded or combination thereof. The filaments in the Silt Filter Fence Fabric must be dimensionally stable (i.e., to each other), resistant to delamination, and must be free from any chemical treatment or coating that might significantly reduce porosity and...
permeability. Both fabrics shall be resistant to ultraviolet radiation. The fabrics shall comply with the following physical properties.

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th>Silt Filter Fence Fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab tensile strength (\text{N(lb.)}) - ASTM D 4632</td>
<td>900 (200) (min.) 1/</td>
</tr>
<tr>
<td>Grab elongation @ break (%) - ASTM D 4632</td>
<td>12 (min.) 1/</td>
</tr>
<tr>
<td>Burst strength (\text{MPa(ksi)}) - ASTM D 751</td>
<td>1.7 (250) (min.) 2/</td>
</tr>
<tr>
<td>Trapezoidal tear strength (\text{N(lb.)}) - ASTM 4533</td>
<td>- - -</td>
</tr>
<tr>
<td>Width (m. (ft.))</td>
<td>1 (3.5) (min.)</td>
</tr>
<tr>
<td>Weight (\text{g/m}^2 \text{(oz/sq.yd.)})</td>
<td>135 (4.0) (min.)</td>
</tr>
<tr>
<td>Equivalent opening size (EOS) Sieve No. - Corps of Construction Coordinators CS - 02215</td>
<td>30 (min.)(nonwoven) 2/</td>
</tr>
<tr>
<td></td>
<td>50 (min.)(woven) 2/</td>
</tr>
</tbody>
</table>

1/ For woven fabric, test results shall be referenced to orientation with warp or weave, whichever the case may be. Both woven and nonwoven fabric shall be tested wet.

2/ Test results may be obtained by manufacturer's certification.

The erosion control fabric fence shall be as shown on the construction plans or equal approved by the Construction Coordinator.

The fabric fence stakes shall be oak wood stakes with minimum dimensions of 1.125" x 1.125 x 52".

2.02 HAY OR STRAW BALEs

Hay or straw bales shall not be utilized.

2.03 BALE STAKES

Shall be four feet minimum length each and be of sound wood 1".

2.04 RIPRAP

Riprap shall be crushed limestone and meet the requirements of Article 1005.01 of the IDOT Standard Specifications for Road and Bridge Construction. Riprap shall meet Quality Designation #C and Gradation #4. Bedding material shall be crushed limestone meeting gradation #1 requirements. Filter fabric shall be as specified in Section 1080.03. Bedding and filter fabric will not be required for the temporary stream widening riprap. Thicknesses of bedding and riprap shall be 6" and 16" respectively. Riprap shall be installed per the provisions of Section 281.04 of the IDOT Standard.

2.05 ROCK DAM

Materials for the rock dam and sediment trap shall be those utilized for Riprap. The rock dam shall be installed as indicated on Standard Drawing IL-660 of the Illinois Urban Manual.
2.06 TEMPORARY SEEDING AND MULCHING

Temporary Seeding and Mulching shall be consistent with Article 880 of the Illinois Urban Manual. Seed Mixture shall be from Table A of said Article and shall be coordinated with Fermi Construction Coordinator for the planting season. Note the provisions of paragraph 3.01 regarding seed mixture enhancements of cereal grains. Hydroseeding shall be used. Mulch shall be straw mulch and placed concurrently with the seeding operation or immediately following.

PART 3. CONSTRUCTION METHODS

3.01 INSTALLATION - GENERAL

The Construction Coordinator has the authority to limit the surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and embankment operations and to require the Subcontractor to provide immediate permanent or temporary pollution control measures. Haul Roads shall be watered continuously during earth moving operations. Cut slopes shall be permanently seeded and mulched as the excavation proceeds to the extent considered desirable and practical.

Slopes that erode easily shall be temporarily seeded as the work progresses with a cereal grain or wheat, rye or oats obtained from a local supplier or seed store. The cereal grains may be planted by a hand seeder or other acceptable method and covered by a drag or harrow to provide a quick cover crop. Inspection of the cereal grain seed will not be required. The intent of using cereal grains as temporary erosion control is to permit the Subcontractor to quickly seed potential areas as the need arises with on-site personnel and equipment.

3.02 FENCE SUPPORTS

The erosion control fence shall be supported on posts at least 6 ft. in length on 5 ft. centers. The fabric shall be installed in a backfilled trench 6 inches deep and securely attached to the posts by any method approved by the Construction Coordinator.

3.03 PLACEMENT

Erosion control fencing and bales shall be placed around all proposed inlets and catch basins as shown on the plans, or as directed by the Construction Coordinator.

3.04 DITCH CHECK INSTALLATION

Ditch checks shall be constructed by the placement of straw bales at intervals of not greater than 300 feet along ditch lines, or as shown on the plans or directed by the Construction Coordinator.

3.05 MAINTENANCE

The temporary erosion control systems installed by the Subcontractor shall be properly maintained as directed by the Construction Coordinator to control erosion and siltation at all times during the life of the contract. If the Subcontractor fails to maintain the temporary erosion control systems as directed by the Construction Coordinator, the Construction Coordinator may, at the expiration of a period of 48 hours, after having given the Subcontractor written notice, proceed to maintain the systems as deemed necessary, and
the cost thereof shall be deducted from any compensation due, or which may become due the Subcontractor under this contract.

3.06 ACCEPTANCE

Upon completion of permanent seeding, the Subcontractor may request an inspection be made, and if satisfactorily completed be relieved of further responsibility for the maintenance of the slopes and seeded areas. Accepted slopes will be documented by the Construction Coordinator in writing.

3.07 REMOVAL

The Subcontractor shall remove temporary erosion control structures when advised to do so by the Construction Coordinator. Ditch checks shall be removed when turf in drainage swales is established as shown in the plans. The areas where erosion control measures are removed shall be seeded and mulched per seeding and mulching specifications herein. The costs associated with the removals shall be incidental to this item.

END OF SECTION 02370
SECTION 02500
ROADWAYS

PART 1. GENERAL

1.01. DESCRIPTION OF THE WORK

A. This work shall consist of furnishing, transporting, and placing materials to construct proposed hot-mix asphalt parking areas, hot-mix asphalt roadways, and aggregate base courses as indicated in the drawings and as directed by the Fermilab Construction Coordinator.

1.02. RELATED WORK

A. Section 02220 – Excavating for Structures and Pavements
B. Section 02221 - Backfilling and Compacting for Structures and Pavements
C. Section 02930 – Fertilizing and Seeding

1.03. QUALITY ASSURANCE

A. Testing and inspection shall be provided by an independent testing firm selected by the Subcontractor; approved by the Construction Coordinator and paid by the Contractor. The testing laboratory shall test all materials submitted for testing by Subcontractor prior to incorporation into the work. Twenty-four hour notice shall be given to the testing laboratory and Construction Coordinator before paving.

1.04. REFERENCES AND STANDARDS


1.05. SUBMITTALS

A. Materials List:

1. Submit required number of copies identifying types and sources of materials proposed for this work.

2. Submit required number of copies identifying mix designs proposed for this work.

3. Submit required number of copies identifying quality control plans proposed for this work.

B. Material Samples:

1. Submit materials for laboratory testing.
PART 2. PRODUCTS AND MATERIALS

A. GEOTEXTILE FABRIC

Geotextile fabric shall be non-woven needle punched furnished and installed in accordance with Article 210 of IDOT Standard Specifications.

B. AGGREGATE BASE COURSE

For areas as noted in the plans, base course shall be crushed limestone, Gradation CA-6 in accordance with Article 1004 of IDOT Standard Specifications. All material shall be crushed stone and shall be placed to the thickness shown on the plans.

C. POROUS GRANULAR EMBANKMENT (AGGREGATE SUB-BASE)

For areas as noted in the plans, porous granular embankment shall be crushed limestone, Gradation CA-1 in accordance with Article 1004 of IDOT Standard Specifications. All material shall be crushed stone and shall be placed to the thickness shown on the plans.

D. AGGREGATE SURFACE COURSE

Material for aggregate surface course shall be crushed limestone Gradation CA-6 in accordance with Article 1004 of IDOT Standard Specifications. All material shall be crushed stone and shall be placed to the thickness shown on the plans.

E. HOT-MIX ASPHALT BINDER AND SURFACE COURSES


2. Mix designs and quality control plans shall be approved by the Fermilab Construction Coordinator prior to application.

F. BITUMINOUS MATERIAL

1. Prime coat (brick/concrete/asphalt): RC-70, SS-1, SS-1h, CSS-1, CSS-1h, HFE 90, SS-1hP, CSC-1hP

2. Prime coat (aggregate): MC-30

PART 3. EXECUTION

A. INSPECTION

Inspect all areas and conditions where asphalt concrete paving and Bituminous Surface are to be placed. Notify the Construction Coordinator in writing of conditions detrimental to proper and timely completion of work.

B. AGGREGATE BASE COURSE
Construct aggregate base course, type A to thickness shown on the plans in accordance with Article 351 of IDOT Standard Specifications. Work includes complete construction of base course indicated on Drawings and typical sections for proposed access roadways. Aggregate base shall be compacted to not less than 95% of Standard laboratory density. A sample of the material shall be provided to the testing laboratory and Construction Coordinator by the Subcontractor fifteen (15) days prior to its use, so that the testing laboratory can test the gradation, quality, and maximum dry density of the material.

C. AGGREGATE SURFACE COURSE

Construct aggregate surface course, type A to thickness shown on the plans in accordance with Article 402 of IDOT Standard Specifications. Work includes complete construction of surface course indicated on Drawings and typical sections for proposed access roadways. Aggregate surface course shall be compacted to not less than 95% of Standard laboratory density. A sample of the material shall be provided to the testing laboratory and Construction Coordinator by the Subcontractor fifteen (15) days prior to its use, so that the testing laboratory can test the gradation, quality, and maximum dry density of the material.

D. POROUS GRANULAR EMBANKMENT (AGGREGATE SUB-BASE)

Construct porous granular embankment to thickness shown on the plans in accordance with Article 207 of IDOT Standard Specifications. Work includes complete construction of porous granular embankment as indicated on the Drawings and typical sections.

E. HOT-MIX ASPHALT BINDER AND SURFACE COURSES

Construct bituminous binder course and surface course to thickness shown on the plans in accordance with Article 406 of IDOT Standard Specifications. Work includes complete construction on prepared subgrades as indicated on drawings and typical sections for proposed service driveway and parking area.

F. BITUMINOUS PRIME COAT

Apply bituminous materials (prime coat) on aggregate base course and between hot-mix asphalt lifts in accordance with Article 406 of the IDOT Standard Specifications. Prime coat shall be applied to the aggregate base course at the rate of 0.30 gal./sq.yd. or as directed by the Fermilab Construction Coordinator. Prime coat shall be applied between hot-mix asphalt lifts at the rate of 0.10 gal./sq.yd. or as directed by the Fermilab Construction Coordinator.

END OF SECTION 02500.
SECTION 02501

CONCRETE SIDEWALKS, APRONS AND STOOPS

PART 1. GENERAL

1.01 DESCRIPTION OF THE WORK

This work shall include the construction of concrete sidewalks, aprons and stoops at locations as shown on the drawings. The dimensions of the aprons and stoops shall be as shown on the plans. The thickness of the stoops and aprons shall be as shown on the plans. The minimum width of sidewalk shall be 4'-0" and minimum thickness shall be 4".

1.02 RELATED WORK

Section 02220 – Excavating for Structures and Pavements
Section 02221 - Backfilling and Compacting for Structures and Pavements

1.03 QUALITY ASSURANCE

Codes and Standards: Comply with local governing regulations if more stringent than herein specified.

1.04 REFERENCES AND STANDARDS


PART 2. PRODUCTS AND MATERIALS

2.01 MATERIALS

A. Forms

1. Steel, wood (must be deeper than 4") or other suitable material of size and strength to resist movement during concrete placement and to retain horizontal and vertical alignment until removal. Use straight forms, free of distortion and defects, extending full depth of concrete. Use flexible spring steel forms or laminated boards to form radius bends as required.

2. Coat forms with form release agent that will not discolor or deface surface of concrete.

B. Reinforcement

6 x 6 W2.9 x W2.9 welded wire fabric conforming to ASTM A-82 or ASTM A-185.
C. Concrete Materials

See Item 2.02 this Section.

D. Expansion Joint Materials

Comply with requirements of Section 1051, Preformed Expansion Joint Filler, Illinois Department of Transportation Standard Specifications for Road and Bridge Construction.

E. Curing and Sealing Compound

Comply with requirements of Sections 1022 Membrane Curing Compound and 1020.15 Portland Cement Concrete, Illinois Department of Transportation Standard Specifications for Road and Bridge Construction.

2.02 CONCRETE MIX, DESIGN AND TESTING

A. Comply with requirements for concrete mix design, sampling and testing, and quality control and as herein specified.

B. Design mix to produce standard-weight concrete consisting of portland cement, aggregate, air-entraining admixture and water to produce following properties.

1. Compressive Strength: 4,000 psi minimum at 28 days.

2. Slump Range: not less than 2" and not more than 5".

3. Air Content: 6% to 8%.

PART 3. EXECUTION

3.01 SURFACE PREPARATION

A. Place and compact a minimum of 6” stone (IDOT CA-6) for sidewalk subbase.

B. Remove deleterious material from the compacted subbase surface immediately before placing concrete.

C. Tamp prepared subbase surface to check for unstable areas and need for additional compaction. Do not begin work until such conditions have been corrected and area ready to receive concrete.

3.02 FORM CONSTRUCTION

A. Set forms to required grades and lines, rigidly braced and secured. Install sufficient quantity of forms to allow continuous progress of the work and so that forms can remain in place at least 48 hours after concrete placement.

B. Check completed formwork for grade and alignment to the following tolerances:
1. Top of forms, not more than 1/8" in 10'.

2. Vertical face on longitudinal axis, not more than 1/4" in 10'.

C. Clean forms after each use and coat with form release agent as often as required to ensure separation from concrete without damage.

3.03 REINFORCEMENT

Locate, place and support reinforcement so that the sidewalk is continually reinforced. Reinforcement must be 1" to 1 2" from forms, and overlapping pieces of reinforcement must overlap 6".

3.04 CONCRETE PLACEMENT

A. General: Comply with requirements for mixing and placing concrete, and as herein specified.

B. Do not place concrete until subbase and forms have been checked for line and grade. Moisten subbase if required to provide a uniform dampened condition at time concrete is placed. Do not place concrete around other structures until required finish elevation and alignment has been set and verified.

C. Spread concrete as soon as it is deposited on subbase, using methods which prevent segregation of mix. Consolidate concrete with internal vibrator along face of forms and adjacent to transverse joints. Keep vibrator away from joint assemblies, reinforcement and side forms. Use only square-faced shovels for hand-spreading and consolidation. Consolidate with care to prevent dislocation of reinforcing and joint devices.

D. Deposit and spread concrete in continuous operation between transverse joints, as far as possible. If interrupted for more than 2 hour, place construction joint.

3.05 JOINTS

A. General

1. Construct expansion, weakened-plane (contraction) and construction joints true to line with face perpendicular to surface of pavement, unless otherwise indicated. Construct transverse joints at right angles to pavement centerline, unless otherwise indicated.

2. When pavement is laid in partial-width slabs, or is joining existing pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.

B. Weakened-Plane (Contraction) Joints - Concrete Walks

1. Provide weakened-plane (contraction) joints at 5'-0” o.c.. Construct weakened-plane joints for depth equal to 3/4” as follow:
a. Tooled Joints: Form weakened-plane joints in fresh concrete by grooving top portion of slabs with recommended cutting tool and finished edges with jointer.

C. Expansion Joints

1. Provide full depth premolded joint filler 2" thick for expansion joints at walk junctions and intersections where walks abut building or platforms. Joints shall be 30'-0" o.c.

2. Extend joint fillers full width and depth of joint. Place top of joint filler flush with finished concrete surface.

3. Furnish joint fillers in one-piece lengths for full width being placed, wherever possible. Where more than one length is required, lace or clip joint filler sections together.

4. Protect top edge of joint filler during concrete placement with a metal cap or other temporary material. Remove protection after concrete has been placed on both sides of joint.

3.06 CONCRETE FINISHING

A. Perform concrete finishing using machine or hand methods as required.

B. After striking off and consolidating concrete, smooth surface by screeding and floating. Use hand methods only where mechanical floating is not possible. Adjust floating to compact surface and produce uniform texture.

C. After floating, test surface for trueness with 10' straight edge. Distribute concrete as required to remove surface irregularities and refloat repaired areas to provide continuous, smooth finish.

D. Work edges of slabs, transverse joints and construction joints with edging tool and round to 1/4" radius, unless otherwise indicated. Eliminate tool marks on concrete surface.

E. After completion of floating and when excess moisture or surface sheen has disappeared, complete surface finishing, as follows:

1. On all surfaces, provide coarse, non-slip finish by scoring surface with stiff-bristled broom, perpendicular to line of traffic.

F. Do not remove forms for 48 hours after concrete has been placed. After form removal, clean ends of joints and point-up minor honeycombed areas. Remove and replace areas or sections of major honeycombing, as directed by the Construction Coordinator.
3.07 CURING AND SEALING

A. Protect and cure finished concrete paving, complying with applicable requirements of Section 1020.13 Portland Cement Concrete, IDOT Standard Specifications for Road and Bridge Construction.

B. Apply two coats of curing and sealing compound in accordance with manufacturer's instructions for newly placed concrete immediately after final finishing.

3.08 REPAIRS AND PROTECTIONS

A. Repair or replace broken defective work, as directed by the Construction Coordinator.

B. Protect pavement from damage until acceptance of work. Maintain sidewalks as clean as possible by removing surface stains and spillage of materials as they occur.

C. Sweep concrete sidewalks and wash free of stains, discolorations, dirt and other foreign material just prior to final inspection.

END OF SECTION 02501.
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SECTION 02607
MANHOLES AND COVERS

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Modular precast concrete electrical manhole sections with tongue-and-groove joints with transition to lid frame, covers, anchorage, and accessories.

RELATED SECTIONS

A. Section 02220 – Excavating for Structures and Pavement.
B. Section 02221 – Backfilling and Compacting for Structures and Pavements.
C. Section 03300 – Cast-in-Place Concrete.
D. Section 16010 – General Electrical Requirements.
E. Section 161100 – Duct Bank.
F. Section 16125 – 15 KV Medium Voltage Cable.

REFERENCES

B. ASTM C478 – Precast Reinforced Concrete Manhole Sections.
D. Commonwealth Edison System Standards.

SUBMITTALS FOR REVIEW

A. Shop Drawings: Indicate manhole locations, elevations, conduit, and sizes and elevations of penetrations for all cast-in place and precast concrete items.
B. Product Data: Provide manhole covers, component construction, features, configuration, and dimension.
C. Design Calculations: Provide design calculations sealed by a licensed Structural Engineer in the State of Illinois.
QUALIFICATIONS

A. Manufacture: Company specializing in manufacturing products specified in this section with minimum three years experience.

QUALITY ASSURANCE

A. All materials supplied and/or manufactured under this Section shall conform to the minimum design, manufacture and installation requirements as specified in the Commonwealth Edison Company System Standards in addition to the requirements specified herein.

B. Design of all manholes shall be made by a licensed Structural Engineer in the State of Illinois in accordance with the minimum design requirements specified herein.

PART 2 PRODUCTS

2.01 MATERIALS

A. Precast manhole shall be furnished complete by one manufacturer and shall consist of a top and bottom casting, grade ring, steel frame and cover, cable racks and miscellaneous hardware and accessories as required for a complete installation. Interior dimensions shall be as detailed in schedules on plans.

B. Concrete shall conform to Section 03300, Cast-In-Place Concrete, in these specifications. Reinforcing steel bars shall be structural grade deformed-type bars and shall meet requirements of ASTM A615.

C. Precast manhole manufacturer shall certify that completed manhole assembly shall meet the following design data:

1. Earth Load = 2 Ft. Fill At 130 Lbs./Ft. 3
2. Surchard = 2 Ft. Fill At 130 Lbs./Ft. 3
3. Live Load = A.A.S.H.T.O. HS-20 Truck With 20% Impact
4. F’c  = 4,500 P.S.I.
5. Fy    = 60,000 P.S.I.
6. Ultimate Strength Design Method

D. This certification shall be included as part of shop drawing submittal.

E. Frame and cover shall be watertight type.

F. Cable racks shall be provided. There shall be a minimum of two (2) supports per triplex cable, per side in manhole.

G. Openings shall be provided in manholes for duct banks installed in field as detailed on plans. These openings shall be located as detailed or as required by manufacturer. All openings shall be sealed watertight after duct bank installation.
PART 3 EXECUTION

3.01 EXAMINATION

A. Verify items provided by other sections of Work are properly sized and located.
B. Verify that built-in items are in proper location, and ready for roughing into Work.
C. Verify excavation for manholes is correct.

3.02 PREPARATION

A. Coordinate placement of inlet and outlet pipe or duct sleeves required by other sections.

3.03 PLACING MANHOLE SECTIONS

A. Place base pad, trowel top surface level.
B. Place manhole sections plumb and level, trim to correct elevations, anchor to base pad.
C. Cut and fit for conduit sleeves.
D. Grout base of shaft sections to achieve slope to exit piping. Trowel smooth. Contour as required.
E. Set cover frames and covers level without tipping, to correct elevations.
F. Coordinate with other sections of work to provide correct size, shape, and location.

END OF SECTION 02607.
SECTION 02619

HIGH DENSITY POLYETHYLENE (HDPE)
SOLID WALL WATER PIPE

PART 1  GENERAL

1.01  SECTION INCLUDES

A. Requirements for High Density Polyethylene (HDPE) pipe used for ICW and DWS service to the new buildings.

1.02  REFERENCES


B. AWWA C906 – Standard for Polyethylene (PE) Pressure Pipe and Fittings, 4-inch through 63-inch, for Water Distribution.

C. AWWA C901 – Standard for Polyethylene (PE) Pressure Pipe and Tubing, ½-inch through 3-inch for Water Service.

1.03  SUBMITTALS

A. Submittals shall conform to requirements of Exhibit A.

B. Submit shop drawings showing design of pipe, fittings, electro fusion couplings, etc., indicating laying dimensions and fabrication.

1.04  PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Comply with Exhibit A requirements. Exercise care in transporting and handling pipe and fittings in order to avoid damage to materials or coatings. Lifting shall be by hoist or on skids when hand lifting is not feasible. Dropping shall not be permitted. Store pipe as recommended by the manufacturer. Damaged pipe and fittings shall be replaced.

1.05  QUALITY CONTROL

A. As a basis for acceptance of the product, the manufacturer shall furnish a certificate of conformance to the specifications.

PART 2  PRODUCTS

2.01  HIGH DENSITY POLYETHYLENE (HDPE) PIPE

A. Pipe and fittings shall conform to AWWA C906, water pressure rating 160 psi, DR11. The pipe will be extruded from resin meeting specifications of ASTM D3350 with a cell classification of PE:345434C; and ASTM D-
1248 pipe grade resin Type III, Class C, Category 5, Grade PE34 polyethylene compound. Fittings shall be molded from a polyethylene compound having a cell classification equal to or exceeding the cell classification of the pipe supplied under this specification.

B. Pipe is to be of solid wall construction and shall have DIPS (Ductile Iron Pipe Size) outside dimensions.

C. Pipe shall be blue or blue striped pipe for potable water application. DR rating and cell classification shall be stamped on pipe.

D. The pipe shall contain no recycle compound except that generated in the Manufacturer’s own plant from resin of the same specification from the same raw material. The pipe shall be homogenous throughout and free of visible cracks, holes, voids, foreign inclusions, or other injurious defects, and shall be nominally identical in color density, melt index and other physical properties throughout.

2.02 INSPECTIONS

A. The Construction Coordinator shall be entitled to inspect pipes or witness pipe manufacturing. Such inspection shall in no way relieve the manufacturer of the responsibilities to provide products that comply with the applicable standards within this specification.

2.03 MARKING AND DELIVERY

A. Each standard and random length of pipe in compliance with this standard shall be clearly marked with the following information:

1. Pipe Size

2. Pipe Class

3. Production Code

4. Material Designation

2.04 TRACER WIRE

A. Provide a 10 gauge insulated copper tracer wire securely fastened onto the pipe during directional drilling pipe installation. This wire conductor shall be used for locating purposes and shall remain intact between manhole/handhole termination points.

PART 3 EXECUTION

3.01 INSTALLATION

A. HDPE potable water pipe shall be installed by trenching methods.
B. Pipe Cleaning During Installing Operation

1. Should the pipe ends become dirty or dusty during the storage of the pipe, a thorough cleaning of the pipe shall be done just before the joint of pipe is fused and installed. At this time, a visual check shall be made by placing the pipe in an inclined position to assure that all foreign material and dirt is removed from the inside of the pipe. The pipe shall be kept clean during and after installation. At the termination of pipe installation, the open end of the pipeline shall be closed off by a suitable cover until installation operations are resumed.

C. Joining HDPE Pipe

1. Sections of polyethylene pipe shall be joined into continuous lengths on the job site above ground. The joining method shall be the butt heat fusion method and shall be performed in strict accordance with the pipe manufacturer’s recommendations. Joining shall utilize controlled temperature and pressure to produce a fused leak-free joint. The butt heat fusion equipment used in the joining procedures shall be capable of meeting all conditions recommended by the pipe manufacturer, including but not limited to, temperature requirements, alignment, and interfacial fusion pressure. Only personnel certified by pipe manufacturer as fusing technicians shall perform this work.

2. HDPE pipe may also be joined as necessary at or near valves and fittings by using approved electro fusion couplings and electro fusion processor. Electro fusion processor shall be “Friatec”, “Central”, or approved equal. Electro fusion processor, cables and accessories shall be given to Fermilab upon the completion of this project.

D. Buried Pipe Anchors for HDPE Pipe.

1. The Subcontractor will be required to install buried pipe anchors for the HDPE piping system when the water main approaches a mechanical joint. Buried pipe anchors shall be as per the manufacturer and shall consist of an appropriate HDPE restraint anchor securely attached to the water main, which shall be adequately encased in concrete at a point in close proximity to the mechanical joint.

E. Mechanical Joints for HDPE Pipe

1. A mechanical connector with restraint capabilities will be required at all mechanical joints. At all locations where the HDPE pipe connects to a mechanical joint with joint restraint, the HDPE pipe shall be equipped with a stainless steel pipe stiffener that fits inside the HDPE pipe.

2. Provide and install Duration Sac-nuts on all mechanical joint fittings. Install six nuts per fitting (three each side). Do not use as a primary nut.
F. Restrained Joints

1. Mega lug restraints shall be installed at interconnections with existing PVC/DIP water mains, mechanical joint bends deflecting 11-1/4 ° or more, and at all mechanical joint fittings in accordance with the manufacturer’s recommendations. Additionally, mega lug restraints shall be installed on all mechanical pipe line joints within 25 feet of any bend or fitting in both directions.

END OF SECTION 02619
SECTION 02630

STORM SEWERS AND CULVERTS

PART 1     GENERAL

1.01    SECTION INCLUDES

A. This section includes furnishing and installing RCP storm sewer, storm manholes and accessories; excavating, bedding, and backfilling at locations shown in the plans.

1.02    RELATED SECTIONS

A. Section 02222 – Excavating, Backfilling and Compacting for Utilities

1.03    MEASUREMENT AND PAYMENT (RESERVED)

1.04    REFERENCE TO STANDARDS


1.05    SUBMITTALS

A. Subcontractor shall submit a letter of certification indicating that all materials within this section meet these specifications herein and IDOT Standard Specifications.

PART 2    PRODUCTS

2.01    GENERAL

A. Products shall conform to the material requirements specified in “Standard Specifications for Water and Sewer Main Construction in Illinois” for PVC sewer pipe and the following modifications and additions.

2.02    PIPE

A. Reinforced concrete pipe (RCP) class IV in accordance with IDOT section 542.

2.03    JOINTS

A. RCP Pipe: Concrete pipe shall be joined by tongue and groove with a rubber gasket joint meeting the requirement of IDOT section 1042.
2.04 MANHOLES

A. Drainage manhole shall conform to the requirements of IDOT Section 602 for precast reinforced concrete manholes.
B. Castings shall conform to the requirements of IDOT section 604.

PART 3 EXECUTION

3.01 GENERAL

A. Installation of reinforced concrete pipe shall conform to the requirements of IDOT Section 550 and installation of structure shall conform to IDOT Section 602.

B. Separation requirements shall conform to the “Standard Specifications for Water and Sewer Main Construction in Illinois”.

END OF SECTION 02630
SECTION 02920

TOPSOIL

PART 1  GENERAL

1.01  DESCRIPTION OF THE WORK

This section includes all material, labor, and equipment to place topsoil on the open and disturbed areas of the site, to the lines and grades shown.

1.02  RELATED WORK

A. Section 02220 – Excavating for Structures and Pavements
B. Section 02221 – Backfilling and Compacting for Structures and Pavements
C. Section 02500 - Roadways

1.03  SUBMITTALS

Representative samples of material proposed for use as topsoil, including test results on clay, sand, and organic contents and pH, shall be submitted to the Construction Coordinator for approval prior to placement of the material.

PART 2.  PRODUCTS AND MATERIALS

2.01  TOPSOIL

Topsoil shall be defined as follows:

Topsoil shall be free from large roots, sticks, weeds, brush, or stones larger than 1 inch in diameter or other litter and waste products. It shall be a loamy mixture having at least 90 percent passing the No. 10 sieve. It shall be free from extraneous materials and shall comply with the following requirements:

It shall contain not less than 1 percent nor more than 10 percent organic matter as determined by the test for organic matter in accordance with AASHTO T 194.

It shall contain not less than 12 percent nor more than 50 percent clay as determined in accordance with AASHTO T 88.

The sand content shall not exceed 55 percent as determined in accordance with AASHTO T 88.

The pH of the sample shall not be lower than 5.0 nor higher than 8.0. The pH shall be determined with an acceptable pH meter on that portion of the sample passing the No. 10 sieve, in accordance with the "Suggested Methods of Tests for Hydrogen Ion Concentration (pH) of Soils" included in the procedures for Testing Soils issued December, 1964 by the American Society for Testing and Materials.
PART 3. EXECUTION

3.01 PLACEMENT

A. General Turf Areas

Under this item, grading will be necessary only at those areas where placement of topsoil will inhibit drainage. At those areas, sufficient material shall be removed to allow topsoil placement without inhibiting the drainage. Placement of the topsoil shall not begin until the Construction Coordinator approves the lines, grades, and condition of the subgrade. If the existing surface has become hardened or crusted, it shall be disked or raked or otherwise broken so as to provide a bond with the layer of topsoil to be applied.

The finished surface shall be free of clods, rocks and shall conform to the lines and grades shown on the plans. No "ponding" will be allowed.

B. Topsoil thickness for the berms are as shown on the plans.

3.02 LIMITS

A. Six inches of topsoil shall be placed on all areas on the site not being paved unless otherwise noted.

B. Topsoil shall be graded to be level with the edge of the paved surface and sloped away from the paved surface.

C. It is not anticipated that topsoil from off-site will be required.

END OF SECTION 02920
SECTION 02930
FERTILIZING AND SEEDING

PART 1 GENERAL

1.01 DESCRIPTION OF THE WORK

This section includes all work necessary to fine grade the site to drain as shown and bring the surface to a uniform plane, to fertilize and prepare the soil for seeding, and to seed the site as specified herein.

1.02 RELATED WORK

A. Section 02220 - Excavating for Structures and Pavements
B. Section 02221 - Backfilling and Compacting for Structures and Pavements
C. Section 02500 - Roadways
D. Section 02920 - Topsoil

1.03 QUALITY ASSURANCE

The work under this section shall be done by subcontractor regularly engaged in the landscape business as it pertains to grading, fertilizing and seeding. The work in this section involves planting seeding mixture. This work shall be done by Subcontractor knowledgeable of seeding mixture and its application.

1.04 SUBMITTALS

The Subcontractor shall submit his plan for executing the work included herein. This submittal shall include fertilizer to be used, information on the type of each seed variety, etc.

1.05 WARRANTY

The seeding Subcontractor shall be responsible for the satisfactory growth of grass and forbs species on all areas seeded until final acceptance of the seeding work.

PART 2 PRODUCTS AND MATERIALS

2.01 SEED MIXTURES FOR LAND MANAGEMENT AREAS, ROADSIDES AND SLOPES

Lb. Per acre

Slope Mix:
Greater than 3-1 Slopes

<table>
<thead>
<tr>
<th>Seed Variety</th>
<th>Lb. Per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Ryegrass</td>
<td>25</td>
</tr>
<tr>
<td>Lolium multiflorum</td>
<td></td>
</tr>
<tr>
<td>Red Top</td>
<td>10</td>
</tr>
<tr>
<td>Plant Name</td>
<td>Seed Count Per Acre</td>
</tr>
<tr>
<td>------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Agrostis alba</td>
<td>20</td>
</tr>
<tr>
<td>Kentucky Blue Grass 98/85</td>
<td>10</td>
</tr>
<tr>
<td>Poa Pratensis</td>
<td></td>
</tr>
<tr>
<td>Hungarian Brome</td>
<td>12</td>
</tr>
<tr>
<td>Bromus inermus</td>
<td></td>
</tr>
<tr>
<td>* Little Bluestem</td>
<td>10</td>
</tr>
<tr>
<td>Schizachyrium scoporium</td>
<td></td>
</tr>
<tr>
<td>* Side Oats Grama</td>
<td>20</td>
</tr>
<tr>
<td>Bouteloua curtipendula</td>
<td></td>
</tr>
<tr>
<td>Mesic Land Management or Roadside Mix: Less than 3-1 Slopes</td>
<td></td>
</tr>
<tr>
<td>Annual Rye Grass</td>
<td>25</td>
</tr>
<tr>
<td>Lolium multiflorum</td>
<td></td>
</tr>
<tr>
<td>Red Top</td>
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<tr>
<td>* Little Blue Stem</td>
<td>10</td>
</tr>
<tr>
<td>Schizachyrium scoporium</td>
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</tr>
<tr>
<td>* Side-Oats Grama</td>
<td>5</td>
</tr>
<tr>
<td>Bouteloua curtipendula</td>
<td></td>
</tr>
<tr>
<td>* Canada Wild Rye</td>
<td>3</td>
</tr>
<tr>
<td>Elymus canadensis</td>
<td></td>
</tr>
</tbody>
</table>

* Native seen in above mixes shall be of local ecotype genetics. (Within 100 miles of Fermilab Site)

2.02 MATERIALS

All seeds shall be guaranteed by the Subcontractor to be true to name and variety. Seed mixtures shall be proportioned by seed count and seed count percentages. The seed counts and seed count percentages indicated per acre in these specifications shall mean the total amount of pure live seed per acre for all species listed except forbs.

At least two weeks prior to the time of seeding, the Subcontractor shall provide to the Construction Coordinator a written description of the seed mixtures showing the percentage of seeds by number of each species. This description shall also include the name and location of the seed supplier, the origin of the various species of seed, a
statement of the purity of the grasses, and the estimated number of seeds per pound of each of the kinds of seed to be furnished.

All seeds shall have the proper stratification and scarification to break seed dormancy. All seeds shall be packed and covered in such a manner as to insure adequate protection against damage and maintain dormancy while in transit, storage, or during planting operations.

PART 3 EXECUTION

3.01 SEEDING LOCATIONS

Subcontractor shall fertilize and seed all disturbed areas within site boundaries.

3.02 SEED BED PREPARATION

After the areas to be seeded have been brought to the proper grades, all boulders, stones larger than one-inch in diameter, debris, and other material shall be removed. The areas shall then be tilled to a depth of at least 3-inches by diskng, harrowing, or other approved method until the condition of the soil is acceptable to the Construction Coordinator. Fertilizer and agricultural limestone shall be distributed uniformly at a rate as determined by the Subcontractor to ensure proper nutrients for establishment of the native grass communities.

3.03 SEEDING METHODS

The seeding subcontractor shall submit a plan and schedule for seeding to the Construction Coordinator at least two weeks prior to the scheduled commencement of the work. The plan shall include a list of the proposed equipment and methods of seeding. Prior to starting work, all seeding equipment shall be calibrated and adjusted to sow seeds at the proper seeding rate. The Construction Coordinator shall be notified at least 48 hours prior to beginning the seeding operations. Seeding operations shall be conducted according to the soil protection chart as shown on the plans. Written permission from Fermilab is required for any adjustment to these dates.

Broadcast Seeding: If a broadcast method of seeding is utilized, no seeds shall be sown during high winds or when the seedbed is not in a proper condition for seeding. Within 12 hours of seeding, all seeded areas shall be rolled at right angles to the runoff with a suitable roller to compact the seedbed and place the seed in contact with the soil. Mulching of the seeded area shall be performed at the discretion of the Sub-Contractor.

No-till or drill seeding: If a rangeland type grass drill or a no-till planter is utilized, rolling of the seedbed is not required. Mulching shall be performed at the discretion of the Subcontractor.

3.04 SEEDING EQUIPMENT

Seeding equipment shall meet the following requirements. Disks shall be weighted if necessary to achieve the required tillage depth. Disks shall have sound, unbroken blades, and shall be in a good state of repair. Rollers or cultipackers shall have rollers at least 6 inches in diameter, and shall be of sufficient weight to pulverize the clods of soil. No-till planters and drills shall be specifically designed for the seeding of native grasses. Any
other equipment utilized by the Subcontractor shall be subject to the approval of the Construction Coordinator.

END OF SECTION 02930.

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SECTION 16010 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 16 Sections. Also refer to Division 1 - General Requirements. This section is also applicable to Fire Alarm Section 16721 and Air Sampling Smoke Detection System Section 16722.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced in each specification section.

1.2 SCOPE OF WORK

A. This Specification and the associated drawings govern furnishing, installing, testing and placing into satisfactory operation the Electrical Systems.

B. The Subcontractor shall furnish and install all new materials as indicated on the drawings, and/or in these specifications, and all items required to make his portion of the Electrical Work a finished and working system.

C. Description of Systems shall be as follows:

1. Electrical power system to and including light fixtures, equipment, motors, devices, etc.

2. Grounding system.

3. Fire alarm system.

4. Emergency power distribution system.

5. Wiring of equipment furnished by others.

1.3 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL, AND CONTROL SUBCONTRACTORS

A. Division of work is the responsibility of the Prime Subcontractor. Any scope of work described at any location on the contract document shall be sufficient for including said requirement in the project. The Prime Subcontractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case shall the project be assessed an additional cost for scope that is described on the contract documents on bid day. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Mechanical Subcontractors" refers to the Subcontractors listed in Division 15 of this Specification.

2. "Technology Subcontractors" refers to the Subcontractors furnishing and installing systems listed in Division 17 of this Specification.
3. Motor Power Wiring: The single phase or 3 phase wiring extending from the power source (transformer, panelboard, feeder circuits, etc.) through disconnect switches and motor controllers to, and including the connections to the terminals of the motor.

4. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case, the devices are usually single phase, have "Manual-Off-Auto" provisions, and are usually connected into the motor power wiring through a manual motor starter.

5. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.

6. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. When the motor power wiring exceeds 120 volts, a control transformer is usually used to give a control voltage of 120 volts.

7. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring that directly powers or controls a motor used to drive equipment such as fans, pumps, etc. This wiring will be from a 120 volt source and may continue as 120 volt, or be reduced in voltage (24 volt), in which case a control transformer shall be furnished as part of the temperature control wiring.

8. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.

9. Low Voltage Technology Wiring: The wiring associated with the Technology Systems, used for analog or digital signals between equipment.

10. Telecommunications Rough-in: Relates specifically to the backboxes, necessary plaster rings and other miscellaneous hardware required for the installation or mounting of telecommunications information outlets.

C. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Subcontractors’ responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors, etc. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals approved. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the
electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Subcontractor.

2. Where the drawings require the Electrical Subcontractor to wire between equipment furnished by the Mechanical Subcontractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Subcontractor shall furnish complete wiring diagrams and supervision to the Electrical Subcontractor and designate the terminal numbers for correct wiring.

3. The Electrical Subcontractor shall establish electrical utility elevations prior to fabrication and installation. The Electrical Subcontractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:
   a. Lighting Fixtures
   b. Gravity flow piping, including steam and condensate.
   c. Sheet metal.
   d. Other piping.
   e. Conduits and wireway.

D. Mechanical Subcontractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment furnished by the Mechanical Subcontractor.

2. Assumes all responsibility for miscellaneous items furnished by the Mechanical Subcontractor that require wiring but are not shown on the electrical drawings or specified in the Electrical Specification. If items such as relays, flow switches, or interlocks are required to make the mechanical system function correctly or are required by the manufacturer, they are the responsibility of the Mechanical Subcontractor.

3. Assumes all responsibility for Temperature Control wiring, if the Temperature Control Subcontractor is a Subcontractor to the Mechanical Subcontractor.

4. This Subcontractor is responsible for coordination of utilities with all other Subcontractors. If any field coordination conflicts are found, the Subcontractor shall coordinate with other Subcontractors to determine a viable layout.

E. Electrical Subcontractor's Responsibility:

1. Furnishes and installs all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Subcontractor in the Mechanical Drawings or Specifications.

2. Installs and wires all remote control devices furnished by the Mechanical Subcontractor or Temperature Control Subcontractor when so noted on the Electrical Drawings.
3. Furnishes and installs motor control and temperature control wiring, when noted on the drawings.

4. Furnishes, installs, and connects all relays, etc., for automatic shutdown of certain mechanical equipment (supply fans, exhaust fans, etc.) upon actuation of the Fire Alarm System.

5. This Subcontractor is responsible for coordination of utilities with all other Subcontractors. If any field coordination conflicts are found, the Subcontractor shall coordinate with other Subcontractors to determine a viable layout.

1.4 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, and any item that may impact coordination with other disciplines.

b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.

d. Maintenance clearances and code-required dedicated space shall be included.

e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. The subcontractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The subcontractors responsible for work defined above shall participate in the coordination drawing process.
2. One subcontractor shall be designated as the Coordinating Subcontractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Subcontractor for this project shall be the Mechanical Subcontractor.

   a. The Coordinating Subcontractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all subcontractors participating in the coordination process and Fermilab.

   a. Scale of drawings:

      1) General plans: 1/4 Inch = 1'-0" (minimum).

      2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).

      3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).

      4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1'-0" (minimum).

      5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.

3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.

4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

1.5 QUALITY ASSURANCE

A. Qualifications:

1. Only products of reputable manufacturers as determined by Fermilab are acceptable.
2. All subcontractors shall employ only workmen who are skilled in their trades. At all times, the number of apprentices at the job site shall be less than or equal to the number of journeymen at the job site.

B. Electronic Media/Files:
1. Construction drawings for this project have been prepared utilizing Revit.
2. Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.
3. If the information requested includes floor plans prepared by others, the Subcontractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.
4. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.
5. The drawings prepared for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.
6. The use of these CAD documents by the Subcontractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

C. Field Measurements:
1. Verify all pertinent dimensions at the job site before ordering any conduit, conductors, wireways, bus duct, fittings, etc.

1.6 SUBMITTALS

A. Refer to Division 1 for submittal requirements.

1.7 PRODUCT DELIVERY, STORAGE, HANDLING AND MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage.

B. Keep all materials clean, dry and free from damaging environments.

C. Coordinate the installation of heavy and large equipment with the General Subcontractor and/or Fermilab. If the Electrical Subcontractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Subcontractor is responsible for moving equipment into the building and/or site. Subcontractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Subcontractor shall
coordinate his/her work with other trades.

PART 2 - PRODUCTS

2.1 GENERAL

A. All items of material having a similar function (e.g., safety switches, panelboards, switchboards, contactors, motor starters, dry type transformers) shall be of the same manufacturer unless specifically stated otherwise on drawings or elsewhere in specifications.

PART 3 - EXECUTION

3.1 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 1.

B. The following must be submitted before final payment:

1. Operation and maintenance manuals with copies of approved shop drawings.

2. Record documents including reproducible drawings and specifications.

3. A report documenting the instructions given to Fermilab's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of this Subcontractor and shall be signed by the Fermilab's representatives.

4. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site and place in location as directed and submit receipt to Fermilab.

5. Inspection and testing report by the fire alarm system manufacturer.

6. Start-up reports on all equipment requiring a factory installation or start-up.

3.2 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for review and approval. The electronic copy shall be corrected as required to address the Fermilab's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by Fermilab.

2. Approved O&M manuals shall be completed and in the Fermilab's possession prior to Fermilab's acceptance and at least 10 days prior to instruction of operating personnel.
B. Electronic Submittal Procedures:

1. Distribution: Submit the O&M manual.

2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.

3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. O&M file name: O&M.div23.subcontractor.YYYYMMDD
   b. Transmittal file name: O&Mtransmittal.div23.subcontractor.YYYYMMDD

5. File Size: Electronic file size shall be limited to a maximum of 4MB. Larger files shall be divided into files that are clearly labeled as “1 of 2”, “2 of 2”, etc.

6. Provide the Fermilab with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title “Operation and Maintenance Instructions”, title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.

7. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Fermilab, Subcontractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.

2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.

3. Copies of all final approved shop drawings and submittals. Include Fermilab’s shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.

4. Copies of all factory inspections and/or equipment startup reports.
5. Copies of warranties.
6. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.
7. Dimensional drawings of equipment.
8. Detailed parts lists with lists of suppliers.
9. Operating procedures for each system.
10. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.
11. Repair procedures for major components.
12. Replacement parts and service material requirements for each system and the frequency of service required.
13. Instruction books, cards, and manuals furnished with the equipment.
14. Include record drawings of the one-line diagrams for each major system. The graphic for each piece of equipment shown on the one-line diagram shall be an active link to its associated Operation & Maintenance data.

3.3 INSTRUCTING FERMILAB’S REPRESENTATIVE

A. Adequately instruct the Fermilab's designated representatives in the maintenance, care, and operation of the complete systems installed under this contract.

B. Provide verbal and written instructions to the Fermilab's representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. Fermilab has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. The instructions shall include:
   1. Maintenance of equipment.
   2. Start-up procedures for all major equipment.
   3. Description of emergency system operation.

E. Notify Fermilab of the time and place for the verbal instructions to the Fermilab's representative so his representative can be present if desired.

F. Minimum hours of instruction time for each item and/or system shall be as indicated in each individual specification section.

G. Operating Instructions:
   1. Subcontractor is responsible for all instructions to the Fermilab’s representatives for the electrical and specialized systems.
   2. If the Subcontractor does not have staff that can adequately provide the required
instructions, he shall include in his bid an adequate amount to reimburse Fermilab for Fermilab to perform these services.

3.4 RECORD DOCUMENTS

A. The following paragraphs supplement the requirements of Division 1.

B. Maintain at the job site a separate and complete set of electrical drawings and specifications with all changes made to the systems clearly and permanently marked in complete detail.

C. Mark drawings and specifications to indicate approved substitutions; Change Orders, and actual equipment and materials used. All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents. Record documents that merely reference the existence of the above items are not acceptable.

D. Record changes daily and keep the marked drawings available for Fermilab's examination at any normal work time.

E. Upon completing the job, and before final payment is made, give the marked-up drawings to Fermilab.

3.5 PAINTING

A. Paint all equipment that is marred or damaged prior to Fermilab's acceptance. Paint and color shall match original equipment paint and shall be obtained from the equipment supplier if available. All equipment shall have a finished coat of paint applied unless specifically allowed to be provided with a prime coat only.

B. Equipment cabinets, casings, covers, metal jackets, etc., located in equipment rooms or concealed spaces, shall be furnished in standard finish, free from scratches, abrasions, chippings, etc.

C. Equipment in occupied spaces, or if standard to the unit, shall have a baked primer with baked enamel finish coat free from scratches, abrasions, chipping, etc. If color option is specified or is standard to the unit, verify with Fermilab color preference before ordering.

3.6 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Fermilab's final acceptance of the project.

B. Clean all foreign paint, grease, oil, dirt, labels, stickers, etc. from all equipment.

C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.7 SPECIAL REQUIREMENTS

A. Coordinate the installation of all equipment, controls, devices, etc., with other trades to maintain clear access area for servicing.
B. Install all equipment to maximize access to parts needing service or maintenance. Review the final location, placement, and orientation of equipment with Fermilab’s representative prior to setting equipment.

C. Installation of equipment or devices without regard to coordination of access requirements and confirmation with Fermilab’s representative will result in removal and reinstallation of the equipment at the Subcontractor’s expense.

3.8 SYSTEM COMMISSIONING

A. The electrical systems shall be complete and operating. System start-up, testing, balancing, and satisfactory system performance is the responsibility of the Subcontractor. This includes all calibration and adjustment of electrical controls, balancing of loads, troubleshooting and verification of software, and final adjustments that may be needed.

B. All operating conditions and control sequences shall be tested during the start-up period. Testing all interlocks, safety shut-downs, controls, and alarms.

1. The Subcontractor and equipment suppliers shall have skilled technicians to ensure that all systems perform properly.

3.9 FIELD QUALITY CONTROL

A. General:

1. Conduct all tests required during and after construction.

2. Supply necessary instruments, meters, etc., for the tests. Supply competent technicians with training in the proper testing techniques.

3. All cables and wires shall be tested for shorts and grounds following installation and connection to devices. Replace shorted or grounded wires and cables.

4. Any wiring device, electrical apparatus or lighting fixture, if grounded or shorted on any integral "live" part, shall have all defective parts or materials replaced.

B. Ground Resistance:

1. Conduct service ground resistance tests using an approved manufactured ground resistance meter. Submit to Fermilab a proposed test procedure including type of equipment to be used. (The conventional ohmmeter is not an acceptable device.)

2. Make ground resistance measurements during normal dry weather and not less than 48 hours after a rain. Ground resistance values shall be verified by Fermi Lab at the time the readings are taken.
3. If the ground resistance value obtained is more than the value set forth in Section 16450, the following shall be done to obtain the value given:
   a. Verify that all connections in the service ground system are secure.
   b. Increase the depth to which ground rods are driven by adding section lengths to the rods and retest. If the resistance is still excessive increase the depth by adding an additional rod section and retest.
   c. If the resistance is still excessive, furnish and install additional ground rods, spaced not less than 20 feet from other ground rods unless otherwise noted on plans, and connect into the ground electrode system. Retest.
   d. Review results with Fermilab.

4. Before final payment is made to the Subcontractor submit a written report to Fermilab including the following:
   a. Date of test.
   b. Number of hours since the last rain.
   c. Soil condition at the time of the test in the ground electrode location. That is: dry, wet, moist, sand, clay, etc.
   d. Diagram of the test set-up showing distances between test equipment, ground electrode, auxiliary electrodes, etc.
   e. Make, model, and calibration date of test equipment.
   f. Tabulation of measurements taken and calculations made.

C. Other Equipment:
   1. Give other equipment furnished and installed by the Subcontractor all standard tests normally made to assure that the equipment is electrically sound, all connections properly made, phase rotation correct, fuses and thermal elements suitable for protection against overloads, voltage complies with equipment nameplate rating, and full load amperes are within equipment rating.

D. If any test results are not satisfactory, make adjustments, replacements and changes as needed and repeat the tests and make additional tests as Fermilab or authority having jurisdiction deem necessary.

END OF SECTION 16010
SECTION 16111 - CONDUIT AND BOXES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Rigid metallic conduit and fittings
B. Intermediate metallic conduit and fittings
C. Electrical metallic tubing and fittings
D. Flexible metallic conduit and fittings
E. Liquidtight flexible metallic conduit and fittings
F. Rigid polyvinyl chloride conduit and fittings
G. Wall and ceiling outlet boxes
H. Electrical connection
I. Pull and junction boxes

1.2 REFERENCES

A. American National Standards Institute (ANSI):
   1. ANSI C80.1 - Rigid Steel Conduit, Zinc-Coated
   2. ANSI C80.3 - Electrical Metallic Tubing, Zinc-Coated and Fittings
   3. ANSI C80.4 - Fittings for Rigid Metal Conduit and Electrical Metallic Tubing
   4. ANSI C80.6 – Intermediate Metal Conduit, Zinc Coated
   5. ANSI/NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports

B. NECA “Standards of Installation”

C. National Electrical Manufacturers Association (NEMA):
   1. ANSI/NEMA FB 1 – Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
   2. RN 1 – Polyvinyl chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
   3. TC 2 – Electrical Polyvinyl Chloride (PVC) Conduit
   4. TC 9 – Fittings for PVC Plastic Utilities Duct for Underground Installation

D. National Fire Protection Association (NFPA):
   1. ANSI/NFPA 70 – National Electrical Code

E. Underwriters Laboratories (UL): Applicable Listings
   1. UL 1 – Flexible Metal Conduit
   2. UL 6 – Rigid Metal Conduit
   3. UL 360 – Liquid Tight Flexible Steel Conduit
   4. UL514-B – Conduit Tubing and Cable Fittings
   5. UL651-A – Type EB and a PVC Conduit and HDPE Conduit
   6. UL651-B – Continuous Length HDPE Conduit
   7. UL746A – Standard for Polymeric Materials – Short Term Property Evaluations
8. UL797 – Electrical Metal Tubing
9. UL1242 – Intermediate Metal Conduit

F. Definitions:

1. Fittings: Conduit connection or coupling.
2. Body: Enlarged fittings with opening allowing access to the conductors for pulling purposes only.
3. Mechanical Spaces: Enclosed areas, usually kept separated from the general public, where the primary use is to house service equipment and to route services. These spaces generally have exposed structures, bare concrete and non-architecturally emphasized finishes.
4. Finished Spaces: Enclosed areas where the primary use is to house personnel and the general public. These spaces generally have architecturally emphasized finishes, ceilings and/or floors.
5. Concealed: Not visible by the general public. Often indicates a location either above the ceiling, in the walls, in or beneath the floor slab, in column coverings, or in the ceiling construction.
6. Above Grade: Not directly in contact with the earth. For example, an interior wall located at an elevation below the finished grade shall be considered above grade but a wall retaining earth shall be considered below grade.
7. Slab: Horizontal pour of concrete used for the purpose of a floor or sub-floor.

1.3 SUBMITTALS

A. Include conduits 1.5” and larger in coordination files. Include all in-floor and underfloor conduit in coordination files. Refer to Section 16010 for coordination drawing requirements.

B. Provide product submittals to Fermilab, per specifications, on floor boxes and slip sleeves for approval prior to purchase and installation.

PART 2 - PRODUCTS

2.1 RIGID METALLIC CONDUIT (RMC) AND FITTINGS

A. Acceptable Manufacturers:


B. Minimum Size Galvanized Steel: 3/4 inch (19mm), unless otherwise noted.

C. Fittings and Conduit Bodies:
   1. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.
   2. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.
   3. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.
   4. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor saddle and clamp. **High impact phenolic threaded type bushings are not acceptable.**
   5. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

D. PVC Externally Coated Conduit: NEMA RN 1; rigid steel conduit with external 20 mil PVC coating and internal galvanized surface. All fittings and conduit bodies shall be complete with coating. Acceptable Manufacturers: Robroy, Permacote, or approved equal.

2.2 INTERMEDIATE METALLIC CONDUIT (IMC) AND FITTINGS

A. Minimum Size Galvanized Steel: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers: Allied, LTV, Steelduct, Wheatland Tube Co, O-Z Gedney, or approved equal.

C. Fittings and Conduit Bodies:
   1. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.
   2. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.
   3. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.
   4. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor
saddle and clamp. **High impact phenolic threaded type bushings are not acceptable.**

5. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

2.3 ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS

A. Minimum Size Electrical Metallic Tubing: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers of EMT Conduit: Allied, LTV, Steelduct, Wheatland Tube Co, or approved equal.

C. Fittings and Conduit Bodies:

1. 2" Diameter or Smaller: Compression type of steel designed for their specific application.

2. Larger than 2": Compression type of steel designed for their specific application.


2.4 FLEXIBLE METALLIC CONDUIT (FMC) AND FITTINGS

A. Minimum Size Galvanized Steel: 3/4 inch, unless otherwise noted. Lighting branch circuit wiring to an individual luminaire may be a manufactured, UL listed 3/8" flexible metal conduit with #12 AWG THHN conductors and an insulated ground wire.

B. Acceptable Manufacturers: American Flex, Alflex, Electri-Flex Co, or approved equal.

C. Construction: Flexible steel, approved for conduit ground, zinc coated, threadless type formed from a continuous length of spirally wound, interlocked zinc coated strip steel. Provide a separate equipment grounding conductor when used for equipment where flexibility is required.

D. Fittings and Conduit Bodies:

1. Threadless hinged clamp type, galvanized zinc coated cadmium plated malleable cast iron or screw-in type, die-cast zinc.

2. Fittings and conduit bodies shall include plastic or cast metal inserts supplied by the manufacturer to protect conductors from sharp edges.

2.5 LIQUIDTIGHT FLEXIBLE METALLIC CONDUIT (LFMC) AND FITTINGS

A. Acceptable Manufacturers: Anaconda Type UA, Electri-Flex Type LA, Alflex, Carlon (Lamson & Sessions), or approved equal.

B. Construction: Flexible steel, approved for conduit ground, zinc coated, threadless type formed from a continuous length of spirally wound, interlocked zinc coated strip steel and an extruded PVC cover.

C. Fittings and Conduit Bodies:
   1. Watertight, compression type, galvanized zinc coated cadmium plated malleable cast iron, UL listed.
   2. Fittings and conduit bodies shall include plastic or cast metal inserts supplied by the manufacturer to protect conductors from sharp edges.
   3. Acceptable Manufacturers: Appleton Electric, O-Z/Gedney Co., Electroline, Bridgeport, Thomas & Betts, Midwest, Regal, Carlon (Lamson & Sessions), or approved equal.

2.6 RIGID NON-METALLIC CONDUIT (PVC) AND FITTINGS

A. Minimum Size Rigid Smooth-Wall Nonmetallic Conduit: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers: Carlon (Lamson & Sessions) Type 40, Cantex, J.M. Mfg., or approved equal.

C. Construction: Schedule 40 and Schedule 80 rigid polyvinyl chloride (PVC), UL labeled for 90°C.

D. Fittings and Conduit Bodies: NEMA TC 3; sleeve type suitable for and manufactured especially for use with the conduit by the conduit manufacturer.

E. Plastic cement for joining conduit and fittings shall be provided as recommended by the manufacturer.

2.7 OUTLET BOXES

A. Sheet Metal Outlet Boxes: ANSI/NEMA OS 1; galvanized steel, minimum of 14 gauge, with 1/2 inch male fixture studs where required.

B. Cast Boxes: NEMA FB1, Type FD, Aluminum or cast feralloy, deep type, gasketed cover, threaded hubs.

C. Outlet boxes for luminaires to be not less than 1-1/2" deep, deeper if required by the number of wires or construction. The box shall be coordinated with surface luminaires to conceal the box from view or provide a finished trim plate.

D. Switch outlet boxes for local light control switches shall be 4 inches square by 2-1/8 inches deep, with raised cover to fit flush with finish wall line. Multiple gang switch outlets shall consist of the required number of gang boxes appropriate to
the quantity of switches comprising the gang. Where walls are plastered, provide a plaster raised cover. Where switch outlet boxes occur in exposed concrete block walls, boxes shall be installed in the block cavity with a raised square edge tile cover of sufficient depth to extend out to face of block or masonry boxes.

E. Wall or column receptacle outlet boxes shall be 4 inches square with raised cover to fit flush with finished wall line. Boxes in concrete block walls shall be installed the same as for switch boxes in block walls.

2.8 ELECTRICAL CONNECTION

A. Electrical connection to equipment and motors, sized per NEC. Coordinate requirements with subcontractor furnishing equipment or motor. Refer to specifications and general installation notes for terminations to motors.

2.9 PULL AND JUNCTION BOXES

A. Sheet Metal Boxes: ANSI/NEMA OS 1; galvanized steel.

B. Sheet metal boxes larger than 12 inches in any dimension that contain terminations or components: Continuous hinged enclosure with 1/4 turn latch and white back panel for mounting terminal blocks and electrical components.

C. Cast Metal Boxes for Outdoor and Wet Location Installations: NEMA 250; Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL listed as raintight. Galvanized cast iron box and cover with ground flange, neoprene gasket, and stainless steel cover screws.

D. Cast Metal Boxes for Underground Installations: NEMA 250; Type 4, inside flanged, recessed cover box for flush mounting, UL listed as raintight. Galvanized cast iron box and plain cover with neoprene gasket and stainless steel cover screws.

E. Flanged type boxes shall be used where installed flush in wall.

PART 3 - EXECUTION

3.1 CONDUIT SIZING

A. Size conduit as shown on the drawings and specifications. Where not indicated in the contract documents, conduit size shall be according to N.E.C. (Latest Edition). Conduit and conductor sizing shall be coordinated to limit conductor fill to less than 40%, maintain conductor ampere capacity as required by the National Electrical Code (to include enlarged conductors due to temperature and quantity derating values) and to prevent excessive voltage drop and pulling tension due to long conduit/conductor lengths.

B. Minimum Conduit Size (Unless Noted Otherwise):

1. Above Grade: 3/4 inch. (The use of 1/2 inch would be allowed for installation conduit to individual light switches, individual receptacles and individual fixture whips from junction box.)
2. Below Grade 5’ or less from Building Foundation: 1 inch.
3. Below Grade More than 5’ from Building Foundation: 1 inch.
4. Telecommunication Conduit: 1 inch.
5. Controls Conduit: 3/4 inch.

C. Maximum Conduit Size Embedded in Slabs above Grade: 3/4 inch for conduits crossing each other.

D. Conduit sizes shall change only at the entrance or exit to a junction box, unless specifically noted on the drawings.

3.2 CONDUIT ARRANGEMENT

A. In general, conduit shall be installed concealed in walls, in finished spaces and where possible or practical, or as noted otherwise. In unfinished spaces, mechanical and utility areas, conduit may run either concealed or exposed as conditions dictate and as practical unless noted otherwise on drawings. Installation shall maintain headroom in exposed vicinities of pedestrian or vehicular traffic.

B. Conduit shall not share the same cell as structural reinforcement in masonry walls.

C. Conduit runs shall be routed as shown on large scale drawings. Conduit routing on drawings scaled 1/4"=1'-0" or less shall be considered diagrammatic, unless noted otherwise. The correct routing, when shown diagrammatically shall be chosen by the Subcontractor based on information in the contract documents, in accordance with manufacturer’s written instructions, applicable codes, the NECA’s "Standard of Installation", in accordance with recognized industry standards, and coordinated with other subcontractors.

D. Subcontractor shall adapt his work to the job conditions and make such changes as required and permitted by Fermilab, such as moving to clear beams and joists, adjusting at columns, avoiding interference with windows, etc., to permit the proper installation of other mechanical and/or electrical equipment.

E. Subcontractor shall cooperate with all Subcontractors on the project. He shall obtain details of other Subcontractor’s work in order to ensure fit and avoid conflict. Any expense due to the failure of This Subcontractor to do so shall be paid for in full by him. The other trades involved as directed by Fermilab shall perform the repair of work damaged as a result of neglect or error by This Subcontractor. The resultant costs shall be borne by This Subcontractor.

3.3 CONDUIT SUPPORT

A. Conduit runs installed above a suspended ceiling shall be properly supported. In no case shall conduit rest on the suspended ceiling construction, nor utilize ceiling support system for conduit support.
B. Conduit shall not be supported from ductwork, water, sprinkler piping, or other non-structural members, unless approved by Fermilab. All supports shall be from structural slabs, walls, structural members, and bar joists, and coordinated with all other applicable subcontractors, unless noted otherwise.

C. Conduit shall be held in place by the correct size of galvanized one-hole conduit clamps, two-hole conduit straps, patented support devices, clamp back conduit hangers, or by other means if called for on the drawings.

D. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

E. Spring-steel conduit clips specifically designed for supporting single conduits or tubing may be used in lieu of malleable-iron hangers for 1-1/2" and smaller raceways serving lighting and receptacle branch circuits above accessible ceilings and for securing raceways to slotted channel and angle supports.

F. Group conduits in parallel runs where practical and use conduit racks or trapeze hangers constructed of steel channel, suspended with threaded solid rods or wall mounted from metal channels with conduit straps or clamps. Provide space in each rack or trapeze for 25% additional conduits.

G. Do not exceed 25 lbs. per hanger and a minimum spacing of 2'-0" on center when attaching to metal roof decking (excludes concrete on metal deck). This 25 lbs. load and 2'-0" spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.

I. Intervals between supports for metallic conduit shall be no greater than 10 feet. A smaller interval may be used if necessitated by building construction, but in no event shall support spans exceed the National Electrical Code requirements. Conduit shall be securely fastened within 3 feet of each outlet box, junction box, device box, cabinet, or fitting.

J. Supports of flexible conduit shall be within 12 inches of each outlet box, junction box, device box, cabinet, or fitting and at intervals not to exceed 4.5 feet.

K. Where conduit is to be installed in poured concrete floors or walls, provide concrete-tight conduit inserts securely fastened to forms to prevent conduit misplacement.

L. Finish:

1. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and above suspended ceiling spaces are not considered exposed.
2. Trim all ends of exposed field fabricated steel hangers, slotted channel and threaded rod to within 1” of support or fastener to eliminate potential injury to personnel unless shown otherwise on the drawings. Smooth ends and install elastomeric insulation with two coats of latex paint if exposed steel is within 6’-6” of finish floor and presents potential injury to personnel.

3.4 CONDUIT INSTALLATION

A. Conduit Connections:

1. Shorter than standard conduit lengths shall be cut square using industry standards. The ends of all conduits cut shall be reamed or otherwise finished to remove all rough edges.

2. Metallic conduit connections in slab on grade installation shall be sealed and one coat of rust inhibitor primer applied after the connection is made.

3. Where conduits with tapered threads cannot be coupled with standard couplings, then approved split or Erickson couplings shall be used. Running threads will not be permitted.

4. Install expansion/deflection joints where conduit crosses structure expansion/seismic joints.

B. Conduit terminations for all low voltage wiring shall have nylon bushings installed on each end of every conduit run.

C. Conduit Bends:

1. Use a hydraulic one-shot conduit bender or factory elbows for bends in conduit 2” in size or larger. All steel conduit bending shall be done cold; no heating of steel conduit shall be permitted.

2. All bends of rigid polyvinyl chloride conduit (PVC) shall be made with the manufacturer’s approved bending equipment. The use of spot heating devices will not be permitted (i.e. blow torches).

3. A run of conduit shall not contain more than the equivalent of four (4) quarter bends (360°), including those bends located immediately at the outlet or body.

4. Rigid polyvinyl chloride conduit (PVC) runs longer than 100 feet or runs which have more than two 90° equivalent bends (regardless of length) shall use rigid metal or RTRC factory elbows for bends.

5. Use conduit bodies to make sharp changes in direction (i.e. around beams).

D. Conduit Placement:

1. Conduit shall be mechanically continuous from source of current to all outlets. Conduit shall be electrically continuous from source of current to
all outlets, unless a properly sized grounding conductor is routed within the conduit. All metallic conduits shall be bonded per the National Electrical Code.

2. Route exposed conduit and conduit above suspended ceilings (accessible or not) parallel/perpendicular to the building structural lines, and as close to building structure as possible. Wherever possible, route horizontal conduit runs above water and steam piping.

3. Route conduit through roof openings provided for piping and ductwork where possible. If not provided or routing through provided openings is not possible, route through roof jack with pitch pocket. Coordinate roof penetrations with other trades.

4. Conduits, raceway, and boxes shall not be installed in concealed locations in metal deck roofing or less than 1.5” below bottom of roof decking.

5. Avoid moisture traps where possible. Where unavoidable, provide a junction box with drain fitting at conduit low point.

6. All conduits through walls shall be grouted or sealed into openings. Where conduit penetrates firewalls and floors, seal with a UL listed sealant. Seal penetrations with intumescent caulk, putty, or sheet installed per manufacturer's recommendations. All materials used to seal penetrations of firewalls and floors shall be tested and certified as a system per ASTM E814 Standard for fire tests or through-penetration fire stops as manufactured by 3M or approved equal. Refer to Section 16080.

7. Conduits that must pass through footers or foundation walls must pass through a reinforced opening coordinated in advance and formed at the time the footer or foundation is constructed.

8. SUBCONTRACTOR SHALL BE RESPONSIBLE FOR ALL OPENINGS REQUIRED IN MASONRY OR EXTERIOR WALLS UNDER THIS DIVISION. A QUALIFIED MASON AT THE EXPENSE OF THIS SUBCONTRACTOR SHALL REPAIR ALL OPENINGS TO MATCH EXISTING CONDITIONS.

9. Seal interior of conduit at exterior entries, air handling units, coolers/freezers, etc., and where the temperature differential can potentially be greater than 20°F, to prevent moisture penetration. Seal shall be placed where conduit enters warm space. Conduit seal fitting shall be a drain/seal, with sealing compound, equal to O-Z/Gedney type EYD.

10. Conduits, if run in concrete structure, shall be in middle one-third of slab thickness, and leave at least 3” min. concrete cover. Conduits shall run parallel to each other and spaced at least 8” apart centerline to centerline. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement. Maximum conduit outside diameter 1".
11. No conduits are allowed in concrete on metal deck unless expressly approved in writing by the Structural Engineer.

12. Do not route conduits across each other in slabs on grade.

13. Rigid polyvinyl chloride conduit (PVC) shall be installed when material surface temperatures and ambient temperature are greater than 40°F.

14. Where rigid polyvinyl chloride conduit (PVC) is used below grade, in a slab, below a slab, etc., a transition to rigid galvanized steel or PVC-coated steel conduit shall be installed before conduit exits earth. The metallic conduit shall extend a minimum of 6" into the surface concealing the non-metallic conduit.

15. Conduits that cross structural expansion joints or transition from underground to building structure shall be provided with an expansion deflection coupling. PVC conduit runs that do not have bends that will accommodate thermal expansion and contraction shall have expansion couplings. Temperature at time of installation of expansion couplings shall be carefully considered against expected temperature range when adjusting installed length of the coupling.

16. Subcontractor shall provide suitable mechanical protection around all conduits stubbed out from floors, walls or ceilings during construction to prevent bending or damaging of stubs due to carelessness with construction equipment.

17. Subcontractor shall provide a polypropylene pull cord with 2000 lbs. tensile strength in each empty conduit (indoor and outdoor), except in sleeves and nipples.

18. Telecommunications conduits that protrude through the structural floor shall be installed 1 to 3" above finished floor (AFF).

19. Telecommunications conduits that enter into Telecommunications rooms below the finished ceiling shall terminate a minimum of 4" below ceiling and as close to the wall as possible.

20. Telecommunications conduits that are below grade and enter into a building shall terminate a minimum of 4" above finished floor (AFF) and as close to the wall as possible.

3.5 CONDUIT TERMINATIONS

A. Where conduit bonding is indicated or required in the contract documents, the bushings shall be a grounding type sized for the conduit and ground bonding conductor as manufactured by O-Z/Gedney, Appleton, Thomas & Betts, Burndy, Regal, or approved equal.

B. Conduits without termination fittings shall be threaded for one (1) lock nut on the outside and one (1) lock nut and bushing on the inside of each box.
C. Where conduits terminate in boxes with knockouts, they shall be secured to the boxes with lock nuts and provided with approved screw type tinned iron bushings or fittings with plastic inserts.

D. Where conduits terminate in boxes, fittings, or bodies with threaded openings, they shall be tightly screwed against the shoulder portion of the threaded openings.

E. Conduit terminations to all motors shall be made with flexible metallic conduit (FMC), unless noted otherwise. Final connections to roof exhaust fans, or other exterior motors and motors in damp or wet locations shall be made with liquidtight flexible metallic conduit (LFMC). Motors in hazardous areas, as defined in the National Electrical Code, shall be connected using flexible conduit rated for the environment. Flexible conduit shall not exceed 6’ in length. Route equipment ground conductors from circuit ground to motor ground terminal through flexible conduit.

F. Rigid polyvinyl chloride conduit (PVC) shall be terminated using fittings and bodies produced by the manufacturer of the conduit, unless noted otherwise. Prepare conduit as per manufacturer's recommendations before joining. All joints shall be solvent welded by applying full even coat of plastic cement to the entire areas that will be joined. Turn the conduit at least a quarter to one half turn in the fitting and let the joint cure for 1-hour minimum or as per the manufacturer's recommendations.

G. All conduit ends shall be sealed with plastic immediately after installation to prevent the entrance of any foreign matter during construction. The seals shall be removed and the conduits blown clear of any and all foreign matter prior to any wires or pull cords being installed.

3.6 UNDERGROUND CONDUIT INSTALLATION

A. Conduit Connections:
   1. Conduit joints in a multiple conduit run shall be staggered at least one foot apart.

B. Conduit Bends (Lateral):
   1. Conduits shall have long sweep radius elbows instead of standard elbows wherever special bends are indicated and noted on the drawings, or as required by the manufacturer of the equipment or system being served.
   2. Telecommunications conduit bend radius shall be six times the diameter for conduits under 2” and ten times the diameter for conduits over 2”. Where long cable runs are involved, sidewall pressures may require larger radius bends. Provide pulling tension calibrations to Fermilab prior to conduit installation to determine bend radius for all duct over 100 feet long or containing over 180°F of bends.
C. Conduit Elbows (vertical):

1. **Minimum** metal or RTRC elbow radiuses shall be 30 inches for primary conduits (>600V) and 18 inches for secondary conduits (<600V). Increase radius, as required, based on pulling tension calculation requirements.

D. Conduit Placement:

1. Conduit runs shall be pitched a minimum of 4" per 100 feet to drain toward the terminations. Duct runs shall be installed deeper than the minimum wherever required to avoid any conflicts with existing or new piping, tunnels, etc.

2. For parallel runs, use suitable separators and chairs installed not greater than 4' on centers. Band conduit together with suitable banding devices. Securely anchor conduit to prevent movement during concrete placement or backfilling.

3. Where concrete is required, the materials for concreting shall be thoroughly mixed to a minimum f'c = 2500 and immediately placed in the trench around the conduits. No concrete that has been allowed to partially set shall be used. Dust top of freshly placed duct bank concrete with red dye.

4. Before the Subcontractor pulls any cables into the conduit he shall have a mandrel 1/4" smaller than the conduit inside diameter pulled through each conduit and if any concrete or obstructions are found, the Subcontractor shall remove them and clear the conduit. Spare conduit shall also be cleared of all obstructions.

5. Conduit terminations in manholes, masonry pull boxes, or masonry walls shall be with malleable iron end bell fittings.

6. All spare conduits not terminated in a covered enclosure shall have its terminations plugged as described above.

7. Ductbanks and conduit shall be installed a minimum of 24" below finished grade, unless otherwise noted on the drawings or elsewhere in these specifications or to achieve proper drainage.

8. All non-metallic conduit installed underground outside of a slab shall be rigid schedule 40 or 80.

E. Raceway Seal:

1. Where a raceway enters a building or structure, it shall be sealed with a sealing bushing or duct seal to prevent the entry of liquids or gases. Seal must be compatible with conductors and raceway system. Spare or unused raceways shall also be sealed.

2. All telecommunications conduits and innerducts, including those containing cables, shall be plugged at the building and vault with
“JackMoon” or equivalent duct seal, capable of withstanding a 10 foot head of water (5 PSI).

3.7 CONDUIT INSTALLATION SCHEDULE

A. In the event the location of conduit installation represents conflicting installation requirements as specified in the following schedule, a clarification shall be obtained from Fermilab. If this Subcontractor is unable to obtain a clarification as outlined above, concealed rigid galvanized steel conduit installed per these specifications and the National Electrical Code shall be required.

B. The following schedule shall be adhered to unless they constitute a violation of applicable codes or are noted otherwise on the drawings. The installation of RMC conduit will be permitted in place of any and all conduit specified in this schedule.

1. Interior Locations:
   a. Switchboards, panel feeders, etc.: IMC.
   b. Branch Circuits (lighting, receptacles, controls, etc.): EMT.
   c. Mechanical Equipment Feeders (pumps, AHU’s, chillers, etc.): EMT.
   d. Floor Mounted Pump Feeders: EMT with no more than 6’ of PVC coated flexible metal conduit to pump.
   e. Controls: EMT painted blue or dyed blue.

2. Wet or Damp Locations: RMC conduit, boxes and fittings, installed and equipped so as to prevent water from entering the conduit system.

3. In or Under Slabs on Grade or Site Conduits:
   a. Within 5’ from the Exterior Perimeter of a Building Foundation: Concrete encased PVC conduit with a minimum of 3” thickness between the surface of the concrete and the nearest conduit. Concrete to be doweled into the foundation.
   b. 5’ or Greater from the Exterior Perimeter of a Building Foundation: PVC unless noted otherwise on the drawings.
   c. Under Roads, Drives, and Vehicle Traveled Ways: Concrete encased PVC with a minimum of 3” concrete cover on all sides of conduit.

4. Hazardous Locations as Defined by the National Electrical Code: RMC conduit complete with screwed fittings and conduit seals.
3.8 BOX INSTALLATION SCHEDULE

A. Galvanized steel boxes may be used in:

1. Concealed interior locations above ceilings and in hollow studded partitions.
2. Exposed interior locations in mechanical rooms and in rooms without ceilings; higher than 8’ above the highest platform level.
3. Direct contact with concrete except slab on grade.

B. Cast boxes shall be used in:

1. Exterior locations.
2. Hazardous locations.
3. Exposed interior locations within 8’ of the highest platform level.
4. Direct contact with earth.
5. Direct contact with concrete in slab on grade.
6. Wet locations.

3.9 COORDINATION OF BOX LOCATIONS

A. Provide electrical boxes as shown on the drawings, and as required for splices, taps, wire pulling, equipment connections, and code compliance.

B. Electrical box locations shown on the Contract Drawings are approximate, unless dimensioned. Verify location of floor boxes and outlets in offices and work areas prior to rough-in.

C. Locate and install boxes to allow access. Avoid interferences with ductwork, piping, structure, equipment, etc. Where installation is inaccessible, provide access doors. Coordinate locations and sizes of required access doors with Fermilab and Subcontractor.

D. Locate and install to maintain headroom and to present a neat appearance.

E. Coordinate locations with Heating Subcontractor to avoid radiant cabinets.

3.10 OUTLET BOX INSTALLATION

A. The Subcontractor shall anchor switch and outlet box to wall construction so that it is flush with the finished masonry, paneling, drywall, plaster, etc. The Subcontractor shall check the boxes as the finish wall surface is being installed to assure that the box is flush. (Provide plaster rings as necessary.)

B. Mount at heights shown or noted on the drawings or as generally accepted if not specifically noted.

C. Locate boxes in masonry walls to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat openings for boxes.

D. Provide knockout closures for unused openings.

E. Support boxes independently of conduit.
F. Use multiple-gang boxes where more than one device are mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.

G. Install boxes in walls without damaging wall insulation.

H. Coordinate mounting heights and locations of outlets mounted above counters, benches, backsplashes, and below baseboard radiation.

I. Position outlets to locate luminaires as shown on reflected ceiling drawings.

J. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioned to allow for surface finish thickness. Use stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.

K. Align wall-mounted outlet boxes for switches, thermostats, and similar devices.

L. Provide cast outlet boxes in exterior locations and wet locations, and where exposed rigid or intermediate conduit is used.

3.11 PULL AND JUNCTION BOX INSTALLATION

A. Locate pull boxes and junction boxes above accessible ceilings or in unfinished areas.

B. Support pull and junction boxes independent of conduit.

3.12 EXPOSED BOX INSTALLATION

A. Boxes shall be secured to the building structure with proper size screws, bolts, hanger rods, or structural steel elements.

B. On brick, block and concrete walls or ceilings, exposed boxes shall be supported with no less than two (2) Ackerman-Johnson, Paine, Phillips, or approved equal screw anchors or expansion shields and round head machine screws. Cast boxes shall not be drilled.

C. On steel structures, exposed boxes shall be supported to the steel member by drilling and tapping the member and fastening the boxes by means of round head machine screws.

D. Boxes may be supported on steel members by APPROVED beam clamps if conduit is supported by beam clamps.

E. Boxes shall be fastened to wood structures by means of a minimum of two (2) wood screws adequately large and long to properly support. (Quantity depends on size of box.)
F. Wood, plastic, or fiber plugs shall not be used for fastenings.

G. Explosive devices shall not be used unless specifically allowed.

END OF SECTION
SECTION 16120 - WIRE AND CABLE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Building wire
B. Remote control and signal cable

1.2 REFERENCES

A. NEMA WC 70 - Power Cables Rated 2,000V or Less for the Distribution of Electrical Energy
B. UL 44 – Thermoset-Insulated Wires and Cables
C. UL 83 – Thermoplastic-Insulated Wires and Cables
D. UL 854 – Service-Entrance Cables
E. UL 1581 – Standard for Electrical Wires, Cables, and Flexible Cords

PART 2 - PRODUCTS

2.1 BUILDING WIRE

A. Feeders and Branch Circuits Larger Than 6 AWG: Copper, stranded conductor, 600 volt insulation, THHN/THWN.
B. Feeders and Branch Circuits Larger than 6 AWG in Underground Conduit: Copper, stranded conductor, 600 volt insulation, THWN.
C. Feeders and Branch Circuits 6 AWG and Smaller: Copper conductor, 600 volt insulation, THHN/THWN. 6 and 8 AWG, stranded conductor; smaller than 8 AWG, solid or stranded conductor, unless otherwise noted on the drawings.
D. Control Circuits: Copper, stranded conductor 600 volt insulation, THHN/THWN.
E. Each 120 and 277 volt branch circuit shall have a dedicated neutral conductor. Neutral conductors shall be considered current-carrying conductors for wire derating.

2.2 REMOTE CONTROL AND SIGNAL CABLE

A. Control Cable for Class 1 Remote Control and Signal Circuits: Copper conductor, 600 volt insulation, rated 60°C, individual conductors twisted together, shielded, and covered with a PVC jacket.
PART 3 - EXECUTION

3.1 WIRE AND CABLE INSTALLATION SCHEDULE

A. Above Accessible Ceilings: Building wire in raceways.
B. All Other Locations: Building wire in raceway.
C. Above Grade: All conductors installed above grade shall be type “THHN”.
D. Underground or In Slab: All conductors shall be type “THWN”.

3.2 WIRE FOR SPECIALIZED SYSTEMS

A. Wire for the following specialized systems shall be as designated on the drawings, or elsewhere in these specifications. If not designated on the drawings or specifications, the system manufacturer's recommendations shall be followed:
   1. Fire alarm
   2. Low voltage switching

3.3 SUBCONTRACTOR CHANGES

A. The basis of design is copper conductors installed in raceway based on ambient temperature of 30°C, NEC Table 310.16. Service entrance conductors are based on copper conductor installed in underground electrical ducts, NEC Table B.310.15(B)(2)(7).

B. The Subcontractor shall be responsible for derating and sizing conductors and conduits to equal or exceed the ampacity of the basis of design circuits, if he/she chooses to use methods or materials other than the basis of design.

C. Underground electrical duct ampacity rating shall be in accordance with NEC Table B.310.15(B)(2)(7) or calculated in accordance with Annex B Application Information for Ampacity Calculation. The calculations and a sketch of the proposed installation shall be submitted prior to any conduit being installed.

D. Record drawing shall include the calculations and sketches.

3.4 GENERAL WIRING METHODS

A. Use no wire smaller than 12 AWG for power and lighting circuits, and no smaller than 14 AWG for control wiring.

B. Use no wire smaller than 18 AWG for low voltage control wiring (<100 volts).

C. Use 10 AWG conductor for 20 ampere, 120 volt branch circuit home runs longer than 75 feet, and for 20 ampere, 277 volt branch circuit home runs longer than 200 feet.

D. Use no wire smaller than 8 AWG for outdoor lighting circuits.
E. The ampacity of multiple conductors in one conduit shall be derated per National Electrical Code, Article 310. In no case shall more than 4 current carrying conductors be installed in one conduit to such loads as motors larger than 1/4 HP, panelboards, motor control centers, etc.

F. Where installing parallel feeders, place an equal number of conductors for each phase of a circuit in same raceway or cable.

G. Splice only in junction or outlet boxes.

H. Neatly train and lace wiring inside boxes, equipment, and panelboards.

I. Make conductor lengths for parallel circuits equal.

J. All conductors shall be continuous in conduit from last outlet to their termination.

K. Terminate all spare conductors on terminal blocks, and label the spare conductors.

L. Cables or wires shall not be laid out on the ground before pulling.

M. Cables or wires shall not be dragged over earth or paving.

N. Care shall be taken so as not to subject the cable or wire to high mechanical stresses that would cause damage to the wire and cable.

O. At least six (6)-inch loops or ends shall be left at each outlet for installation connection of luminaires or other devices.

P. All wires in outlet boxes not connected to fixtures or other devices shall be rolled up, spliced if continuity of circuit is required, and insulated.

3.5 WIRING INSTALLATION IN RACEWAYS

A. Pull all conductors into a raceway at the same time. Use UL listed wire pulling lubricant for pulling 4 AWG and larger wires.

B. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.

C. Pulling shall be continuous without unnecessary stops and starts with wire or cable only partially thru raceway.

D. Where reels of cable or wire are used, they shall be set up on jacks close to the point where the wire or cable enters the conduit or duct so that the cable or wire may be unreeled and run into the conduit or duct with a minimum of change in the direction of the bend.

E. Conductors shall not be pulled through conduits until plastering or masonry work is completed and conduits are free from moisture. Care shall be taken so that long pulls of wire or pulls around several bends are not made where the wire may be permanently stretched and the insulation damaged.
F. Only nylon rope shall be permitted to pull cables into conduit and ducts.

G. Completely and thoroughly swab raceway system before installing conductors.

H. Conductor Supports in Vertical Raceways:
   1. Support conductors in vertical raceways in accordance with NEC 300.19 and Table 300.19(A) Spacing of Conductors Supports.
   2. Supports shall be of insulated wedge type (OZ Gedney Type S, or equal) and installed in a tapered insulated bushing fitting or a metal woven mesh with a support ring that fits inside conduit fitting installed in an accessible junction box (Hubbell Kellems support grip or equal).

3.6 WIRING CONNECTIONS AND TERMINATIONS

A. Splice and tap only in accessible junction boxes.

B. Use solderless, tin-plated copper, compression terminals (lugs) applied with circumferential crimp for copper conductor terminations, 8 AWG and larger.

C. Use solderless, tin-plated, compression terminals (lugs) applied with indenter crimp for copper conductor terminations, 10 AWG and smaller.

D. Use solderless pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and smaller. For 10 AWG and smaller, use insulated spring wire connectors with plastic caps.

E. Use copper, compression connectors applied with circumferential crimp for copper wire splices and taps, 6 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of conductor.

F. Thoroughly clean wires before installing lugs and connectors.

G. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.

H. Phase Sequence: All apparatus shall be connected to operate in the phase sequence A-B-C representing the time sequence in which the phase conductors so identified reach positive maximum voltage.

I. Unless extenuating circumstances require, and only with prior approval by Fermilab connections to switches, circuit breakers, starters, panelboards, switchgear and the like, arrangement phase conductors shall be:
   1. Facing the front and operating side of the equipment, the phase identification shall be:
      a. Left to Right - A-B-C
      b. Top to Bottom - A-B-C
J. Connection revisions as required to achieve correct rotation of motors shall be made at the load terminals of the starters or disconnect switches.

3.7 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Division 1.

B. Building Wire and Power Cable Testing: Refer to Section 16950.

C. Inspect wire and cable for physical damage and proper connection.

D. Torque test conductor connections and terminations to manufacturer's recommended values.

E. Perform continuity test on all power and equipment branch circuit conductors. Verify proper phasing connections.

END OF SECTION 16120
SECTION 16622 - PACKAGED ENGINE GENERATOR SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Packaged engine generator system
B. Exhaust silencer and fittings
C. Fuel fittings and day tank
D. Remote annunciator panel
E. Battery and charger
F. Weatherproof enclosure

1.2 REFERENCES

A. ANSI/NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
B. ANSI/NEMA MG 1 - Motors and Generators
C. ANSI/NFPA 70 - National Electrical Code
D. ANSI/NEMA AB 1 - Molded Case Circuit Breakers
E. NFPA 37 – Installation and Use of Stationary Combustion Engines and Gas Turbines
F. NFPA 110 – Emergency and Standby Power Systems
G. Environmental Protection Agency EPA Emission Standards for Compressed Ignition Engines

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 16010.
B. Submit shop drawings showing plan and elevation views with overall and interconnection point dimensions, fuel consumption rate curves at various loads, ventilation and combustion air requirements, and electrical diagrams including schematic and interconnection diagrams.
C. Submit product data showing dimensions, weights, ratings, interconnection points, and internal wiring diagrams for engine, generator, control panel, battery, battery rack, battery charger, exhaust silencer, vibration isolators, day tank, remote radiator, and remote annunciator.
D. Submit certificates for compliance with EPA Emissions Standards for Compressed Ignition Engines.
E. Submit manufacturer’s installation instructions under provisions of Section 16010.

1.4 EXTRA MATERIALS

A. Submit maintenance materials under provisions of Section 16010.
B. Furnish one set of tools required for preventative maintenance of the engine generator system. Package tools in adequately sized metal toolbox.

C. Provide two additional sets of each fuel, oil, and air filter element required for the engine generator system. Provide additional fuel polishing filters for one year of operation.

D. Provide one fuse for every type and rating used.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 16010.

B. Store and protect products under provisions of Section 16010.

C. Accept packaged engine generator set and accessories on site in crates and verify damage.

D. Protect equipment from dirt and moisture by securely wrapping in heavy plastic.

1.6 SYSTEM DESCRIPTION

A. Engine generator system to provide source of emergency and standby power.

B. System Capacity: 100 KW, 125 KVA at an elevation of 1,000 feet above sea level, and ambient temperature between -20°F and 110°F; standby rating using engine-mounted radiator.

C. Emergency Power Supply System (EPSS) shall be NFPA 110 Type 10 Class 12 Level 2.


1.7 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 16010 for required generator electronic CAD drawings to be provided to Coordinating Subcontractor for inclusion into composite coordination drawings. Show generator, fuel system components, battery system components, and exhaust system in 1/4” scale plan of room.

1.8 PROJECT RECORD DOCUMENTS

A. Submit record documents under provisions of Section 16010.

B. Accurately record location of engine generator and mechanical and electrical connections.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 16010.
B. Include instructions for normal operation, routine maintenance requirements, service manuals for engine and day tank, oil sampling and analysis for engine wear, and emergency maintenance procedures.

1.10 QUALIFICATIONS
A. Manufacturer: Company specializing in packaged engine generator system with minimum five (5) years documented experience.
B. Supplier: Authorized distributor of engine generator manufacturer with service facilities within 50 miles of the project site.

1.11 WARRANTY
A. Provide a two (2) year warranty under provisions of Section 16010.

1.12 MAINTENANCE SERVICE
A. Furnish service and maintenance of packaged engine generator system for one (1) year from Date of Substantial Completion. Maintenance service shall be performed by skilled employees of manufacturer's designated service organization. Include quarterly exercising, and routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Maintenance agreements shall include parts, supplies, and labor.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS
A. Cummins Power Generation.
B. Caterpillar.
C. Kohler.

2.2 PACKAGED ENGINE-GENERATOR SET
A. Packaged engine-generator set shall be a coordinated assembly of compatible components.
B. Safety Standard: Comply with ASME B15.1 and UL 2200.
C. Nameplates: Each major system component shall be equipped with a nameplate to identify manufacturer's name and address, model and serial number, and component rating in integrated set and as required by the contract documents.
D. Fabricate engine-generator set mounting frame and attachment of components to resist generator-set movement during a seismic event when generator-set mounting frame is anchored to building structure.
E. Mounting Frame: Adequate strength and rigidity to maintain alignment of mounted components without depending on concrete foundation. Mounting frame shall be free from sharp edges and corners and shall have lifting attachments arranged for lifting with slings without damaging components. Provide a rigging
diagram permanently attached to the mounting frame to indicate the capacity of each lifting attachment and the generator-set center of gravity.

2.3 ENGINE

A. Type: Water-cooled in-line or V-type, compression ignition diesel electric ignition internal combustion engine.

B. Rating: Sufficient to operate at 100 percent load for two hours at specified elevation and ambient limits.

C. Fuel: Appropriate for use of No. 2 fuel oil.

D. Engine Speed: 1800 RPM.

E. Governor: Isochronous type with speed sensing.

F. Safety Devices: Engine shutdown on high water temperature, low oil pressure, overspeed, and engine overcrank. Limits as selected by manufacturer.

G. Frequency Response:
   1. Steady State Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
   2. Transient Response: Less than 5 percent for a 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady state operating band within 5 seconds.

   1. Base-Mounted Fuel Tank: UL listed fuel tank with 12 hour rated (NFPA 110 minimum run time by class) capacity. Integral rupture basin with leak detection. Provide fueling port with an overfill prevention type receptacle and lockable cap for exterior units. The tank shall include structural steel supports for top mounted engine generator set. Furnish complete with flexible fuel line connectors lockable cover, and analog level gauge. Furnish complete with float switches to indicate low 5% 25% 50% and 75% fuel level.

I. Engine Jacket Heater: Thermal circulation type water heater with integral thermostatic control, sized to maintain engine jacket water at 90°F, and suitable for operation on 208-1Ø volts AC. The minimum wattage of the heater shall be as recommended by the manufacturer.

J. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator set mounting frame and integral engine-driven coolant pump.
   1. Fan and Core: Nonferrous-metal construction sized to contain expansion of total system. Blower type fan, sized to maintain safe engine temperature in ambient temperature of 110°F. Radiator Airflow Restriction: 0.5 inches of water, maximum.
2. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anti-corrosive additives.

3. Provide expansion tank with gage glass and petcock, and self-contained, thermostatic-control temperature control valve.

K. Engine Starting: DC starting system with positive engagement, number and voltage of starter motors in accordance with manufacturer's instructions. Include remote starting control circuit, with MANUAL-OFF-REMOTE selector switch on engine-generator control panel. Provide the following accessories:

1. Battery: Voltage to match starter with capacity for three cranking cycles without recharge. Provide with battery cables and acid resistant battery tray.

2. Battery-Charging Alternator: Factory mounted on engine with solid state voltage regulation.

3. Battery Charger: Current limiting type designed to float at 2.17 volts per cell and equalize at 2.33 volts per cell. Include overload protection, full wave rectifier, DC voltmeter and ammeter, and 120 volts AC fused input. Provide wall-mounted enclosure to meet ANSI/NEMA 250, Type 1 requirements.

L. Exhaust System: Critical type silencer (85 dBA max at 10 feet), side inlet with muffler companion flanges and flexible stainless steel exhaust fitting, suitable for horizontal orientation, sized in accordance with engine manufacturer's instructions. Silencer shall include a threaded opening for connection of ¾” drain line. Opening shall be flush on inside of silencer.

M. The packaged engine generator shall comply with the current Environmental Protection Agency EPA Emissions standards.

N. Engine Accessories: Fuel filter, lube oil filter, intake air filter, lube oil cooler, fuel transfer pump, fuel priming pump, gear-driven water pump. Include fuel pressure gauge, water temperature gauge, and lube oil pressure gauge on engine-generator control panel.

O. Mounting: Provide unit with suitable spring-type vibration isolators.

2.4 GENERATOR

A. Generator: ANSI/NEMA MG 1; three phase, re-connectible brushless synchronous generator with brushless exciter and PMG alternator excitation.

B. Rating: As indicated on the drawings, at 0.8 power factor, 60 Hertz at RPM to match engine rating.

C. Insulation: ANSI/NEMA MG 1, Class F.

D. Temperature Rise: 105°C continuous.

E. Enclosure: ANSI/NEMA MG 1; open drip-proof.
F. Voltage Regulation:
   1. The maximum instantaneous voltage dip (IVD) shall be 30 percent.
   2. Include solid-state type voltage regulator, separate from exciter to match
      engine and generator characteristics, with voltage regulation ±1 percent
      from no load to full load. Include manual controls to adjust voltage drop
      ±5 percent voltage level, and voltage gain.

G. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

H. Strip Heater: Thermostatically controlled unit arranged to maintain stator
   windings above dew point.

2.5 CONTROLS AND INDICATION

A. Operating and safety indications, protective devices, basic system controls, and
   engine gauges shall be grouped in a common control and monitoring panel
   mounted on the generator set. Mounting method shall isolate the control panel
   from generator–set vibration.

B. Ground Fault: Provide ground fault sensing at the generator. The sensor shall
   be located ahead of the generator service disconnect. Provide a ground fault
   indication on the engine-generator control panel. Provide an instruction
   nameplate at the control panel.

   1. Instruction nameplate: Provide operational instructions for a ground fault
      indication as approved by the local Authority Having Jurisdiction.

C. Engine-Generator Control Panel: ANSI/NEMA 250, Type 1 generator mounted
   control panel enclosure with engine and generator controls and indicators.
   Include provision for padlock and the following equipment and features:

   1. Alarm indication as required by NFPA 110 for a Level 2 system.
   2. AC frequency meter.
   3. AC output voltmeter with phase selector switch.
   4. AC output ammeter with phase selector switch.
   5. Output voltage adjustment.
   6. DC voltmeter (alternator battery charging).
   7. Engine start/stop selector switch.
   8. Engine running time meter.
   9. Oil pressure gauge.
  10. Engine coolant temperature gauge.
  11. Shut down devices for overspeed, coolant high-temperature, coolant low-
      level, and oil low-pressure.
  14. Auxiliary Relay: 3PDT, operates when engine runs, with contact terminals
      prewired to terminal strip.
  15. Remote Alarm Contacts: Pre-wire SPST contacts to terminal strip for
      remote alarm functions required by ANSI/NFPA 99.
D. Remote Engine Annunciator Panel: ANSI/NFPA 99 and NFPA 110 for a Level 2 system. Include the listed pre-alarm and alarm points, audible alarm, alarm silencing means, repetitive alarm circuitry, and lamp test switch in a surface mounted panel with brushed stainless steel finish. Provide all interconnecting wiring in conduit per manufacturer's requirements by the Electrical Subcontractor. The remotely reported alarms shall include the following.

1. Overcrank
2. Low water (engine) temperature
3. High engine temperature prealarm
4. High engine temperature
5. Low lube oil pressure prealarm
6. Low lube oil pressure
7. Overspeed
8. Low fuel main tank
9. Low coolant level
10. Not in auto
11. Emergency Power Supply (EPS) supplying load
12. High battery voltage
13. Low battery voltage
14. Battery charger failure (includes AC failure)
15. Generator running
16. Normal utility power
17. Emergency stop
18. Rupture basin alarm
19. Emergency Power Off Switch activated (EPO)

E. Building Automation System Integration:

1. Provide a terminal block to allow the Facility Monitoring and Control System (FMCS) to report generator alarms. Provide individual terminal points for each of the annunciator alarms and pre-alarms. Provide an additional terminal point to combine all of the generator alarms under a single terminal point. Provide a permanent label for each terminal point. Each terminal will provide a binary output for the FMCS to read. Refer to Specification Section 15952 for alarms reported by the FMCS.

2.6 ACCESSORIES

A. Generator Circuit Breaker: Molded or insulated case, service-rated thermal-magnetic type; 100% rated breaker complying with NEMA AB1 and UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator rating.
3. Shunt Trip: Connected to trip breaker when generator is shut down by other protective devices.
4. Mounting: Provide freestanding enclosure or mount integrally with control and monitoring panel.
B. Remote Manual Stop Station (Emergency Power Off EPO): Provide a remote manual stop station with weather proof stainless steel or die cast housing, red mushroom button - push to stop operation, breakable cover/lens to access mushroom button, 120 volt rated. The manufacturer shall provide automatic monitoring of the EPO switch. Placing the EPO switch in the "Generator Powered OFF" status shall initiate a visual and audible alarm at each generator annunciator panel.

2.7 OUTDOOR GENERATOR-SET ENCLOSURE SKIN-TIGHT

A. Prefabricated or pre-engineered skin tight enclosure with the following features:

1. Construction: Reinforced galvanized steel, metal clad, integral structural steel framed housing anchored to a concrete foundation. Panelized aluminum housing with integral structural framing anchored to a concrete foundation. Construction shall allow access to control panels and service points. The panels shall enclose all components, including intake/exhaust louvers and sound attenuators. Extend the enclosure base frame as required for panels.

2. The generator control panel shall be located no greater than 5'-0" above finished grade for ease of access.

3. Structural Design and Anchorage: Wind resistant up to 100 mph.

4. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents. Motor operators shall be spring open, power close operating at 24 volts DC. The louvers shall be connected to the generator starting batteries through appropriate control relays. Louvers shall not extend outside main generator enclosure.

5. Hinged Doors: Provide a minimum of four doors with padlocking provisions. Single doors shall be 36" wide and 84" high. Double doors shall be 60" wide and 84" high. As standard, doors shall include rain-rail moldings above all door openings, recessed, keyed mortise locks, panic bar door hardware and full weather-stripping. Doors shall be removable.

6. Thermal Insulation: Manufacturer’s standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits as required by engine-generator-set components.

7. Fuel Tank Vent: Provide vent piping from the fuel tank to the exterior of the enclosure.

8. Fuel Fill: Provide fill access on the exterior of the enclosure at an elevation not to exceed 5'-0" above finished grade.

9. The exhaust system silencer shall be installed within the enclosure housing.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work and field dimensions are as shown on the drawings.

B. Verify that required utilities are available in proper location and ready for use.

C. Beginning of installation means installer accepts existing conditions.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install remote manual stop station in location shown on plans. Provide 120 Volt power and wiring in conduit as required. Coordinate installation with the manufacturer approved shop drawings and wiring diagrams. The remote manual stop station shall shunt trip the generator mounted circuit breaker and signal the engine prime mover to stop.

C. The A-B-C phase rotation of the generator source shall match the A-B-C phase rotation of the utility source. The Subcontractor shall verify the generator and utility phase rotation match to prevent three phase motors and similar loads from operating backwards while being served by the generator.

3.3 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 16010and in compliance with NFPA 110 requirements.

B. Provide portable test bank for full load test, if required. Simulate power failure including operation of transfer switch, automatic starting cycle, and automatic shutdown, and return to normal.

C. Fill fuel tank prior to start of test.

D. The on-site installation test shall be conducted as follows:

1. With the prime mover in a “cold start” condition and the emergency load at standard operating level, a primary power failure shall be initiated by opening all switches or breakers supplying the primary power to the building or facility.

2. The test load shall be that load that is served by the Emergency Power Supply System (EPSS).

3. The time delay on start shall be observed and recorded.

4. The cranking time until the prime mover starts and runs shall be observed and recorded.
5. The time taken to reach operating speed shall be observed and recorded.

6. The voltage and frequency overshoot shall be recorded.

7. The time delay on transfer to emergency power for each switch shall be recorded. Life safety and critical branch transfer switches must transfer within 10 seconds.

8. The time taken to achieve a steady-state condition with all switches transferred to the emergency position shall be observed and recorded.

9. The voltage, frequency, and amperes shall be recorded.

10. The prime mover oil pressure and water temperature shall be recorded, where applicable.

11. The battery charge rate shall be recorded at 5-minute intervals for the first 15 minutes and at 15 minute intervals thereafter.

12. When primary power is returned to the building or facility, the time delay on retransfer to primary for each switch with a minimum setting of 5 minutes shall be recorded.

13. The time delay on the prime mover cool down period and shutdown shall be recorded.

14. Allow prime mover to cool for 5 minutes.

15. A load shall be applied for 4 hours total. The building load shall be permitted to serve as part or all of the load, supplemented by a load bank of sufficient size to provide a load equal to 100 percent of the nameplate rating of the Emergency Power Supply (EPS), less applicable derating factors for site conditions. Observe and record load changes and the resultant effect on voltage and frequency.

16. The full load test shall be initiated immediately after the cooling time has expired by any method that starts the prime mover and, immediately upon reaching rated rpm, picks up 100 percent of the nameplate kW rating on one step, less applicable derating factors for site conditions.

17. During test, record the following at 5-minute intervals for the first 15 minutes and every 15 minutes for the rest of the test:

   a. Kilowatts
   b. Amperes
   c. Voltage
   d. Frequency
   e. Coolant temperature
   f. Enclosure temperature (interior)
   g. Oil pressure
   h. Engine exhaust temperature
   i. Engine inlet temperature
j. Oil Temperature
k. Battery charge rate

18. Upon completion of the test and after a cool down period, the crank/rest cycle shall be tested.
   a. Any method recommended by the manufacturer for the cycle crank test shall be utilized to prevent the prime mover from running.
   b. The control switch shall be set at “run” to cause the prime mover to crank.
   c. The complete crank/rest cycle shall be observed and recorded.

19. Test alarm and shutdown circuits by simulating conditions.

E. Subcontractor shall fill fuel tanks upon completion of test.
F. Testing documentation shall be submitted to Fermilab for review and approval.
G. Generator testing worksheets are included with this specification section.

3.4 MANUFACTURER'S FIELD SERVICES
A. Prepare, start, test, and adjust systems under provisions of Section 16010.

3.5 ADJUSTING
A. Adjust generator output voltage and engine speed.

3.6 CLEANING
A. Clean work under provisions of Section 16010.
B. Clean engine and generator surfaces. Replace oil and fuel filters.

3.7 DEMONSTRATION
A. Provide systems demonstration. Coordinate the demonstration schedule with Fermilab.
B. Describe loads connected to emergency and standby systems and restrictions for future load additions.
C. Simulate power outage by interrupting normal source, and demonstrate that system operates to provide emergency and standby power.

END OF SECTION 16622
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<th>ELAPSED DURATION</th>
<th>1 VOLTS</th>
<th>2 VOLTS</th>
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<th>1 AMPS</th>
<th>2 AMPS</th>
<th>3 AMPS</th>
<th>KW</th>
<th>TARGET KW</th>
<th>HZ</th>
<th>HOUR METER</th>
<th>P.F.</th>
<th>OIL PRESS.</th>
<th>FUEL PRESS.</th>
<th>AMBIENT AIR TEMP.</th>
<th>ENGINE WATER TEMP.</th>
<th>EXHAUST TEMP.</th>
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SECTION 16950 - TESTING ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section prescribes the basic minimum requirements for field testing and inspection of electrical equipment and work.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Refer to previous Sections which describe items of related Work. Coordinate Work prescribed by this Section with Work prescribed in previous sections.

1.3 RELATED TECHNICAL REQUIREMENTS

A. Project sections.
B. Subcontract drawings.
C. Manufacturer’s instruction manuals, drawings, and information applicable to the apparatus, equipment and systems.

1.4 RELATED WORK

A. Examine all portions of the Subcontract documents for work related to the work of this Section. Provide all work hereunder as required for the support and accommodation of related work.

PART 2 - CONDITIONS

2.1 GENERAL

A. The work of this section is subject to the Fermilab Construction Subcontract Terms and Conditions and to Exhibit A, SCHEDULE AND SUPPLEMENTARY TERMS AND CONDITIONS.

2.2 APPLICABLE STANDARDS

A. The publications listed below form part of this Section. Each publication shall be the latest revision and addendum in effect on the date of subcontract award, unless noted otherwise. Except as specifically modified by the requirements specified herein or the details on the drawings, the Work included under this Section shall conform to the provisions of these publications:

1. ANSI (American National Standards Institute):

2. IEEE (Institute of Electrical and Electronics Engineers).

3. NEMA (National Electrical Manufacturers Association).

4. NETA (National Electrical Testing Association).
PART 3 - EXECUTION

3.1 GENERAL

A. This Section provides guidelines for the inspection, testing, and checkout of the electrical systems to ensure that the electrical installation is in accordance with the design sections, drawings, and manufacturer's instructions.

B. The listings and descriptions of the inspections, tests, and checks described herein shall not be considered as complete and all inclusive. Additional normal standard construction (and sometimes repetitive) checks and tests may be necessary throughout the course of the Work.

C. Medium voltage cable testing shall be performed by an independent subcontractor in accordance with NETA (National Electrical Testing Association).

1. Independent testing subcontractor will be selected and supervised by Fermilab and paid by the Subcontractor.

2. Coordination of cable testing shall be arranged under this subcontract (cable installation subcontract) to provide Fermilab and testing subcontractor with ample time and notice. Cable installation subcontractor shall provide the Fermilab Construction Coordinator 24-hours notice of time and period available for cable testing.

3. Cable installation subcontractor shall provide a knowledgeable workman to be present at all times during the cable testing. Workman's duties and responsibilities shall include, but not be limited to, verification of cables to be tested, removal of end boots or seals, verification of all safety precautions, keeping manholes free from water and acting as subcontractor's representative for verification of cable test results.

4. Independent cable testing subcontractor is responsible for hi-pot testing as cables (only) as described on Form #65F1104, attached.

5. All other testing and reporting as described herein shall be the responsibility of the cable installation subcontractor.

D. The checks and tests shall be documented on the attached Quality Control Forms. Quality Control Forms shall be available for Fermilab review at any time during the Subcontract. Completed Quality Control Forms shall be given to the Fermilab Construction Coordinator at the conclusion of the Subcontract.

E. Subcontractor shall be responsible for all inspection and test activities. The detail implementation plan shall be reviewed and approved by the Fermilab Construction Coordinator.

F. Equipment or circuitry shall not be energized, de-energized, or tied-in to a system without prior review and approval of the test plan and procedure, prepared and submitted by the Subcontractor.

3.2 TESTING AND INSPECTION OF EQUIPMENT AND CABLE

A. Preparation:
1. A detailed plan and schedule shall be prepared for inspection and testing activities.

2. Manufacturer, make, model, serial numbers, and dates of latest calibration of the instruments used shall be recorded on the test forms.

3. Testing and checkout work shall be performed with fully qualified personnel skilled in the particular tests being conducted. This is essential for obtaining and properly evaluating data while the tests are in progress, and for ensuring that important facts and questionable data are reported.

4. The test supervisor shall ensure that testing and checkout work is conducted in a safe manner. Special safety precautions such as the following shall be utilized:
   a. Lockout and tagout procedures.
   b. Barricades.
   c. De-energization or isolation of equipment before testing.
   d. Review of procedures with safety personnel.
   e. Erection of warning signs.
   f. Stationing of guards and watchmen.
   g. Maintenance of voice communications.
   h. Personnel orientation.
   i. Project Hazard Analysis and Job Hazard Analysis as required.

5. The test apparatus shall be of the proper voltage class and rating for the test being performed. Care shall be taken that the installation shall not be overstressed.

6. At any stage of construction and/or when electrical equipment or systems are determined to be damaged, faulty, or requiring repairs, the electrical equipment or systems shall be reported to the Fermilab Construction Coordinator. Corrective action may require prior approval.

3.3 INSPECTION AND TEST OF ELECTRICAL INSTALLATION

   A. Additional inspections may be carried out by Fermilab. Fermilab inspection shall not alleviate the requirement for inspection as defined herein.

PART 4 - ATTACHMENTS

Attachment 6:
Form: 65F1300: Electrical Punch List Record

Attachment 7:
Form: 65F1200: Underground Conduit (Duct Bank) Inspection Checklist
Attachment 9:
Form: 65F1202: Aboveground Conduit Inspection Checklist

Attachment 10:
Form: 65F1100: Conduit Sealing Inspection Record

Attachment 12:
Form: 65F1204: Cable Pulling Inspection Checklist

Attachment 13:
Form: 65F1101: Insulation Resistance Test Record

Attachment 15:
Form: 65F1205: Medium and High Voltage Cable Termination Inspection Checklist

Attachment 16:
Form: 65F1103: Medium and High Voltage Cable Splice Inspection Record

Attachment 17:
Form: 65F1104: DC High Potential Test (Medium Voltage Cable) Test Record

Attachment 18:
Form: 65F1105: Ground/Earthing System (Grid or Loop Type System) Inspection Record

Attachment 21:
Form: 65F1108: Ground Continuity (Non-electrical Equipment/Structures) Test Record

Attachment 23:
Form: 65F1110: Panelboard Inspection Record

Attachment 42:
Form: 65F1129: Electric Motor Run-In Test Record
## ELECTRICAL PUNCH LIST RECORD

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<th>Identification &amp; Location</th>
<th>Remarks</th>
<th>Date Corrected</th>
<th>Supervisor’s Approval</th>
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**DISTRIBUTION**

**SUBCONTRACTOR/DATE**

__________________________
NOTE: THIS CHECKLIST SHALL BE USED DURING THE INSPECTION OF UNDERGROUND UTILITIES

1. Trenching checked for location, elevation and forming. Check for conflicts with other construction.

2. Conduit size, type and location checked for conformance to Sections and drawings.

3. Minimum concrete coverage will be in accordance with Sections on all sides of conduits.


5. Stub-up dimensions and location checked.

6. Field bend radius correct in accordance with drawings/Section bends free of deformities.

7. Pipe caps on all ends.

8. All conduit connections tightly made.

9. Reinforcing bars installed when specified.

10. All field changes recorded on as-built drawings.

11. Trench or forms free of debris.

12. Concrete coverage adequate, spacers not left exposed.

13. Concrete color in accordance with Sections.


15. Backfill and compaction correct.

16. Conduits free of such things as stoppages and grout leakage.
# Aboveground Conduit Inspection Checklist

## Date:  

## Rev.:

### Note:
This checklist shall be used during the inspection of conduit.

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<th>Description</th>
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<td>1</td>
<td>Supports and spacing in accordance with Sections, codes &amp; drawings</td>
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<td>2</td>
<td>Supports adjacent to terminal fittings.</td>
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<tr>
<td>3</td>
<td>Conduits clean, stub-ups protected, open ends plugged, damage during construction repaired</td>
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<tr>
<td>4</td>
<td>Field bend radius correct in accordance with Sections and codes. Bends free of deformities.</td>
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<tr>
<td>5</td>
<td>Expansion joints as required.</td>
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<tr>
<td>6</td>
<td>Installation neat and evenly spaced</td>
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<td>7</td>
<td>Conduit permanently and effectively grounded, unless Sections permit otherwise. Bonding jumpers installed around inspection joints.</td>
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<tr>
<td>8</td>
<td>Proper fittings installed with threads fully engaged; no wrench cuts, conduit ends have bushings and covers installed</td>
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<tr>
<td>9</td>
<td>Drains installed in accordance with Sections.</td>
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<tr>
<td>10</td>
<td>RGS, PVC or PVC-coated conduit installed when specified on drawings</td>
</tr>
<tr>
<td>11</td>
<td>Flexible conduits installed with proper bending radius and with standard fittings.</td>
</tr>
<tr>
<td>12</td>
<td>Junction boxes leveled and supported with proper hubs, locknuts and bushings installed, in accordance with drawings. Junction boxes properly identified.</td>
</tr>
<tr>
<td>13</td>
<td>Adequate number of pulling points.</td>
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## Distribution  

## Subcontractor/Date

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SBN Far Detector Building  

SECTION 16950  
ATTACHMENT 9  
FORM: 65F1202  

ABOVEGROUND CONDUIT INSPECTION CHECKLIST  

NOTE: THIS CHECKLIST SHALL BE USED DURING THE INSPECTION OF CONDUIT

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</tr>
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<tr>
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<td>12</td>
<td>Junction boxes leveled and supported with proper hubs, locknuts and bushings installed, in accordance with drawings. Junction boxes properly identified.</td>
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<tr>
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<td>Adequate number of pulling points.</td>
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## Distribution  

## Subcontractor/Date

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# CONDUIT SEALING INSPECTION RECORD

**DATE:**
**REV:**
**BUILDING:**
**AREA/UNIT:**
**PANEL BOARD TAG:**

**NOTE:** THIS CHECKLIST SHALL BE USED DURING THE INSPECTION OF CONDUIT SEALS

1. Receiving Operations/Inspection complete.
2. Equipment Protection Program instituted and documented.
3. Check assembly for any missing parts.
4. Enclosure approved for area classification.
5. Panelboard circuit schedule filled out.
6. Correct circuit breaker fuse size and location.
8. Grounding/earthing installed and connected. Test Record, Form 000.265.F1109.
9. Ground Continuity Test Record (Electrical Equipment & Ground Test Bars), completed.
10. Seals installed (if required).
11. Check for breather and drain.
12. Check panel load balance.
13. Check color-coding of branch circuit conductors.
15. Check mounting and supports.
16. Fixtures and receptacles are correct type and installed as per drawings.
17. Fixtures and receptacles on correct circuit.
18. Nameplate, number of circuits and panelboard location per drawing.
19. Correct glands installed (i.e., flameproof glands on explosion-proof enclosures.).
20. Megger buses including neutral. Record results on Form 65F1124.
21. Insulation Resistance (Equipment) Test Record. Main disconnect & outgoing circuits should be open.
22. Equipment Protection Program completed and documented.
23. Final inspection complete. Punch items on Form 65F1300, Electrical.
24. Punch List Record, cleared.

**DISTRIBUTION**

**SUBCONTRACTOR/DATE**
### CABLE PULLING INSPECTION CHECKLIST

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<td></td>
<td>1.</td>
<td>Check that conduit has been swabbed-out and any standing water removed.</td>
</tr>
<tr>
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<td>2.</td>
<td>Check that number of pulling points is adequate and the number of bends between pulling points does not exceed Section or code requirements.</td>
</tr>
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<td>3.</td>
<td>Check cable reel assignments and cutting schedules.</td>
</tr>
<tr>
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<td></td>
<td>4.</td>
<td>Check cable voltage rating, minimum pulling temperature and type of pulling compound.</td>
</tr>
<tr>
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<td></td>
<td>5.</td>
<td>Inspect cables for jacket damage.</td>
</tr>
<tr>
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<td></td>
<td>6.</td>
<td>Ambient temperature within manufacturer’s recommended installation limits.</td>
</tr>
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<td>7.</td>
<td>Monitor pulling tension on critical pulls and verify that maximum permitted tension not exceeded in accordance with tension data.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>8.</td>
<td>Perform DC High Potential Test (hypot) on medium and high voltage cables (rated over 2000 volts) and record on Test Record, Form 65F1104, DC High Potential Test Record (Medium Voltage Cable).</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>9.</td>
<td>Bend radius of trained cable is in accordance with Sections and cable is free of kinks.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>10.</td>
<td>Installation is neat and cable lay (maintained spacing) in accordance with Sections.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>11.</td>
<td>Cables identified in accordance with Sections and drawings.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>12.</td>
<td>Cable ends sealed after cutting.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>13.</td>
<td>Manhole grounding system installed.</td>
</tr>
<tr>
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<td></td>
<td>14.</td>
<td>Cable neutral conductors grounded.</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>15.</td>
<td>Cables firewrapped in manholes.</td>
</tr>
</tbody>
</table>

**DISTRIBUTION**

**SUBCONTRACTOR/DATE**
## INSULATION RESISTANCE TEST RECORD

<table>
<thead>
<tr>
<th>Panel No.</th>
<th>Feeder No.</th>
<th>Circuit No.</th>
<th>Wire Tagging</th>
<th>Cable-Rated Voltage</th>
<th>Quantity</th>
<th>Size</th>
<th>From</th>
<th>To</th>
<th>Insulation Resistance (Megaohms)</th>
<th>Initials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

Cable-rated voltage (ohms) ________________________________

Test duration ________________________________

Resistance for cable quality ________________________________

Cable/wire size or amperage (megaohms) ________________________________

Resistance when cable connected to equipment ________________________________

DISTRIBUTION ________________________________

SUBCONTRACTOR/DATE ________________________________
# MEDIUM AND HIGH VOLTAGE CABLE TERMINATION INSPECTION CHECKLIST

<table>
<thead>
<tr>
<th>Check Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cable size, type, location, installation and routing in accordance with drawings.</td>
</tr>
<tr>
<td>2. Bend radius in accordance with specifications and cable jacket free of kinks.</td>
</tr>
<tr>
<td>3. Cable termination supports and support spacing in accordance with drawings and specifications.</td>
</tr>
<tr>
<td>4. Installation neat and evenly spaced.</td>
</tr>
<tr>
<td>5. Cable free of surface damage.</td>
</tr>
<tr>
<td>6. Termination kit/materials installed in accordance with manufacturer’s instructions.</td>
</tr>
<tr>
<td>7. Document DC High Potential Test (hypot) on Form 65.F1104, DC High Potential Test Record (Medium Voltage Cable), or obtain appropriate documentation from testing Subcontractor.</td>
</tr>
<tr>
<td>8. Cable terminated in accordance with equipment manufacturer’s instructions including torquing of bolted connections.</td>
</tr>
<tr>
<td>9. Check phase location and marking: Left to Right, Top to Bottom, or Front to Rear, in accordance with specifications requirements.</td>
</tr>
<tr>
<td>A. Acceptable</td>
</tr>
<tr>
<td>B. Acceptable</td>
</tr>
<tr>
<td>C. Acceptable</td>
</tr>
<tr>
<td>10. Metallic Sheaths/Shields/Armor grounded/earthed in accordance with manufacturers recommendations.</td>
</tr>
</tbody>
</table>

**NOTE:** This Inspection Checklist shall be used for terminations rated greater than 2000 volts. Inspection Record

**CIRCUIT NO.:**

**KIT MANUFACTURER:**

**KIT NO.:**

**DATE:**

**REV.:**

**DISTRIBUTION**

**SUBCONTRACTOR/DATE**
## MEDIUM AND HIGH VOLTAGE CABLE SPLICE INSPECTION TEST RECORD

<table>
<thead>
<tr>
<th>DATE:</th>
<th>REV.:</th>
</tr>
</thead>
</table>

NOTE: This Inspection Record shall be used for cables rated greater than 2000 volts.

<table>
<thead>
<tr>
<th>REFERENCE DWG.</th>
<th>SPLICE NO.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>SPLICE KIT</th>
<th>MANUFACTURER</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>KIT NO</th>
<th>KIT NO</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>CIRCUIT NO</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>FROM</th>
<th>TO</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>CABLE RATED VOLTAGE</th>
<th>CABLE TYPE</th>
</tr>
</thead>
</table>

1. **Location**
   - Manhole Number

2. **Splice Make-up:**
   - A. Acceptable
   - B. Acceptable
   - C. Acceptable
   - Neutral Acceptable

3. **Document DC High Potential Test (hypot) on Form 65F1104, DC High Potential.**
   - Test Record (Medium voltage Cable), or obtain appropriate documentation from testing Subcontractor.

4. **Sheath grounded/earthed, as required**

5. **Field changes recorded on as-built drawings.**

6. **Splice markers installed.**

**DISTRIBUTION**

**SUBCONTRACTOR/DATE**
SECTION 16950
ATTACHMENT 17
FORM: 66F1104
DC HIGH POTENTIAL TEST (MEDIUM VOLTAGE CABLE) TEST RECORD

<table>
<thead>
<tr>
<th>DATE:</th>
<th>REV.:</th>
</tr>
</thead>
</table>

CIRCUIT NUMBER: 

REF DWG.: 

CABLE SIZE: (SQMM) (MCM)

FROM: TO: 

NUMBER OF CONDUCTORS: NUMBER OF SPLICES: 

CABLE LENGTH MANUFACTURER: 

INSULATION TYPE: THICKNESS: 

JACKET MATERIAL: 

WEATHER: TEMP: ° C ° F HUMIDITY: % 

DATE: 

TEST EQUIPMENT USED: 

NOTES:

1. The test voltage shown below shall be reached in 10 equal voltage increments.

2. After each voltage increase, the leakage current shall be allowed to stabilize during a 1 minute interval. If 1 minute intervals are insufficient to stabilize the current, the cable shall be discharged, and the test repeated with new time intervals of greater, but still equal duration.

3. Record the stabilized leakage current, in microamps, at the end of each time interval.

4. Allow the voltage to remain constant at the full test voltage and record the leakage current for 5 minutes for unshielded cables and 15 minutes for shielded cables.

5. Read test equipment instruction manual prior to testing cable.

6. When Project specifies the plotting of test results, attach 2ND sheet with separate plot for each phase. Note leakage current, in microamps, on “y” axis. Note step-voltage increase on “x” axis, followed by time, in minutes, for the dielectric absorption portion of the test.

7. All other phases and shields to be grounded.
Voltage Hold Time

At Each Step:

<table>
<thead>
<tr>
<th>sec</th>
<th>Kv</th>
<th>Kv</th>
<th>Kv</th>
<th>Kv</th>
<th>Kv</th>
<th>Kv</th>
<th>Kv</th>
<th>Kv</th>
<th>Kv</th>
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<tbody>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>sec</th>
<th>min</th>
<th>min</th>
<th>min</th>
<th>min</th>
<th>min</th>
<th>min</th>
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</tr>
</thead>
<tbody>
<tr>
<td>At Kv</td>
<td>30</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
</tr>
</tbody>
</table>

CABLE RATED VOLTAGE (kilovolts)  TEST VOLTAGE (kilovolts)

Tester’s Initials  Date

DISTRIBUTION  SUBCONTRACTOR/DATE
SECTION 16950
ATTACHMENT 18
FORM: 65F1105
GROUNDING/EARTHING SYSTEM INSPECTION RECORD
(GRID OR LOOP-TYPE SYSTEM)

<table>
<thead>
<tr>
<th>DATE:</th>
<th>REV.:</th>
<th>REF. DWG.:</th>
</tr>
</thead>
</table>

NOTE: This Inspection Checklist shall be used for installation and checking of Main Grounding/Earthig System.

1. Primary conductor is correct size and type in accordance with drawings.

2. Ground/earthing conductor burial depth and routing per drawings and Sections.

3. Thermal/compression connections checked (no cold joints or burn-outs).

4. Thermal/compression connection insulation checked.

5. Ground/earthing anode locations and installation per drawing.


7. Location, type, size and insulation color of equipment taps per drawings and protected during construction.

8. System ground/earthing anode resistance-to-earth checked and recorded on Form 65F1106, Ground/Earthing Anode Testing Test Record (Attachment 19).

9. All field Revisions recorded on as-built drawings.

DISTRIBUTION

SUBCONTRACTOR/DATE
SECTION 16950  
ATTACHMENT 21  
FORM: 65F1108  

GROUNDING CONTINUITY TEST RECORD  
(NON-ELECTRICAL EQUIPMENT/STRUCTURES)

<table>
<thead>
<tr>
<th>DATE:</th>
<th>REV.:</th>
<th>REF. DWG.:</th>
</tr>
</thead>
</table>

TEST EQUIPMENT  
USED: __________________ WEATHER: __________________

### 1.3

<table>
<thead>
<tr>
<th>Equipment Tag No. Or Structure</th>
<th>Drawing</th>
<th>Measured Resistance (ohms)</th>
<th>Initials &amp; Date</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

DISTRIBUTION  
SUBCONTRACTOR/DATE  
___________________
## PANELBOARD INSPECTION RECORD

<table>
<thead>
<tr>
<th>DATE:</th>
<th>REV.:</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING:</td>
<td>AREA/UNIT:</td>
</tr>
</tbody>
</table>

1. Receiving Operations/Inspection complete.
2. Check assembly for any missing parts.
3. Enclosure approved for area of installation.
4. Panelboard circuit schedule filled out.
5. Correct circuit breaker and location. Verify exact model number and rating of each conduit breaker matches submitted shop drawings. Update shop and record drawings as needed.
7. Grounding/earthing installed and connected. Test Record, (Form 54F1109, Attachment 22) Ground Continuity Test Record (Electrical Equipment and Ground Test Bars), completed.
8. Check panel load balance.
9. Check color-coding of branch circuit conductors.
10. Clean out.
11. Check mounting and supports.
12. Fixtures and receptacles are correct type and installed as per drawings.
13. Fixtures and receptacles on correct circuit.
14. Nameplate, number of circuits and panelboard location per drawing.
15. Megger buses (including neutral). Record results on Form 65F1124 (Attachment 37), Insulation Resistance (Equipment) Test Record. Main disconnect and outgoing circuits should be open.
16. Final inspection complete. Punch items on Form 65F1300, Electrical Punch List Record, cleared.

**DISTRIBUTION**

**SUBCONTRACTOR/DATE**

---

**TESTING ELECTRICAL SYSTEMS**

2 MARCH 2015

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ISSUED FOR 90% REVIEW
### ELECTRIC MOTOR RUN-IN TEST RECORD

<table>
<thead>
<tr>
<th>TEST</th>
<th>REMARKS</th>
<th>INITIALS/DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESISTANCE (in ohms):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bonding resistance measured from motor frame to Main ground/earth system tap.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOLTAGE (in volts):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual voltage measured at Motor Control Center</td>
<td></td>
<td></td>
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<tr>
<td>ROTATION CHECK:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bump motor to verify rotation. Motor shall be Uncoupled.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO LOAD CURRENT (in aamps):</td>
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</tr>
<tr>
<td>At beginning of test:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At end of test:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEMPERATURE OF BEARING:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check bearing for high temperature:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before start:</td>
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<tr>
<td>15 minutes after start:</td>
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<tr>
<td>30 minutes after start:</td>
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<tr>
<td>1 hour after start:</td>
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<tr>
<td>2 hours after start:</td>
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<td></td>
</tr>
<tr>
<td>3 hours after start:</td>
<td></td>
<td></td>
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<tr>
<td>VIBRATION:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Make visual inspection during run-test.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Record any unusual vibration in remarks column.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOISE:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Record any unusual noise in remarks column.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DISTRIBUTION**

**END OF SECTION 16950**

**TESTING ELECTRICAL SYSTEMS**

2 MARCH 2015

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**ISSUED FOR 90% REVIEW**