CITY OF DETROIT
MAYOR MIKE DUGGAN

TECHNICAL SPECIFICATIONS

FOR

Runway 7-25 Land Sale – Phase 2

AT

COLEMAN A. YOUNG AIRPORT
DETROIT, MICHIGAN

ISSUED FOR BID
May 15, 2025

PREPARED BY

Kimley»Horn
of Michigan, Inc.

ISSUED FOR BID

TECHNICAL SPECIFICATIONS

FOR

Runway 7-25 Land Sale – Phase 2

AT

COLEMAN A. YOUNG INTERNATIONAL AIRPORT
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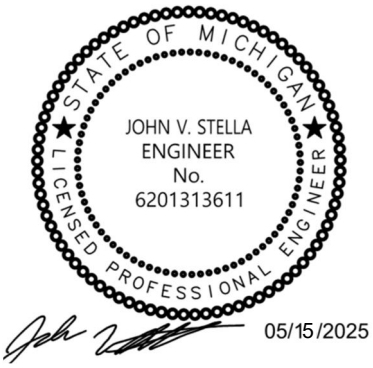

TECHNICAL – KIMLEY-HORN
Sections: SX-120, SX-125, DX-800
P-153, L-108, L-109, L-110, L-115, L-125, MDOT-110, MDOT-201, MDOT-202-, MDOT-203, MDOT-204, MDOT-205, MDOT-208, MDOT-302, MDOT-308, MDOT-402, MDOT-403, MDOT-404, MDOT-501, MDOT-603, MDOT-808, MDOT-811, MDOT-816, MDOT-818, CDET-003

TABLE OF CONTENTS

FAA TECHNICAL SPECIFICATIONS

Section Title
SX-120 – Safety and Security
SX-125 – Erosion Control Inspection Permit
DX-800 – Soft Digs
P-153 – Controlled Low-Strength Material
L-108 – Underground Power Cable for Airports
L-109 – Airport Transformer Vault and Vault Equipment
L-110 – Airport Underground Electrical Duct Banks
L-115 – Electrical Manholes and Junction Structures
L-125 – Installation of Airport Lighting

REFERENCES

FAA-C-1391d Installation, Termination, Splicing, and Transient Surge Protection of Underground Electrical Distribution System Power Cables
FAA-E-2042c Cable Control Exterior
FAA-E-2072c Cable Telephone Exterior

MDOT TECHNICAL SPECIFICATIONS

Section Title
110 – Mobilization
201 – Clearing
202 – Removing Trees, Stumps, and Corduroy
203 – Removing Drainage Structures, Culverts, and Sewers
204 – Removing Miscellaneous Structures and Materials
205 – Roadway Earthwork
208 – Soil Erosion and Sedimentation Control
302 – Aggregate Base Course
308 – Geosynthetics for Base
402 – Storm Sewers
403 – Drainage Structures
404 – Underdrains
501 – Plant Produced Hot Mix Asphalt
603 – Concrete Pavement Restoration
808 – Fencing
811 – Permanent Pavement Markings
816 – Turf Establishment
818 – Electrical

CITY OF DETROIT TECHNICAL SPECIFICATIONS

Section Title

003 – Excavation, Backfilling, Grading and Removals

END OF TABLE OF CONTENTS

Item SX-120 Safety and Security

DESCRIPTION

120-1.1 **General.** This work shall consist of complying with the provisions of the operational phasing plan, the Coleman A. Young Airport, and the City of Detroit. The Contractor shall have a complete and thorough understanding of all safety and security procedures and requirements contained in the contract documents that is required to ensure safety during construction.

MATERIALS

120-2.1 **Low Profile Barricade.** The Contractor shall provide low profile barricades in accordance with the Contract Documents. Relocation of barricades will not be measured and shall be considered incidental.

120-2.2 **Safety Fence.** The Contractor shall provide safety fence in accordance with the Contract Documents.

METHOD OF MEASUREMENT

120-3.1 **Low Profile Barricade.** Low profile barricades furnished and placed will be measured per each. Relocation of barricades will not be measured and shall be considered incidental.

120-3.2 **Safety Fence.** Safety fence will be measured per linear foot. Relocation of safety fence will not be measured and shall be considered incidental.

BASIS OF PAYMENT

120-4.1 **Low Profile Barricade.** Low profile barricades will be paid for at the contract unit price per each. This price shall constitute full compensation for furnishing material and equipment, set up, relocation during each phase, removal, maintenance thereof, and all other labor, materials, equipment, tools and incidentals necessary to accomplish this item.

120-4.2 **Safety Fence.** Safety fence will be paid for at the contract unit price per linear foot. This price shall constitute full compensation for furnishing material and equipment, set up, relocation, removal, maintenance thereof and all other labor, materials, equipment, tools and incidentals necessary to accomplish this item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
SX-120-4.1	Temporary Safety Fence	Linear Foot (LF)
SX-120-4.2	Low Profile Barricade	Each (EA)
SX-120-4.3	Low Profile Barricade - Bid Alt 1	Each (EA)

END OF ITEM SX-120

Item SX-125 Erosion Control Inspection Permits

DESCRIPTION

102-1.1 This item shall consist of the NPDES and Soil Erosion and Sedimentation Control (SESC) permit applications required for approval of the temporary control measures as shown on the plans or as ordered by the Engineer during the life of a contract to control pollution of air and water, soil erosion, and siltation through the use of silt fences, berms, dikes, dams, sediment basins, fiber mats, gravel, mulches, grasses, slope drains, and other erosion control devices or methods.

Temporary control measures shall be designed, installed and maintained to minimize the creation of wildlife attractants that have the potential to attract hazardous wildlife on or near public-use airports.

102-1.2 Owner will submit the SESC permit application to Wayne County for review. The contractor shall be responsible for obtaining the SESC permit and paying all inspection fees.

The permit will cover the area inside the project limits. The permit does not include nor cover the Contractor's haul routes, equipment access points, staging areas, office compounds, materials stockpiles, blending and batch plant areas and operations or other project related activity areas outside the project limits or off site.

102-1.3 The Contractor shall prepare all required documentation, pay all fees and perform all services and work necessary to obtain all permits and approvals from any and all local, state and federal regulatory agencies for the Contractor's staging, stockpile, blending and batch plant areas and operations. The cost of all permitting shall be subsidiary to the other items of work.

102-1.4 The Contractor shall develop a Pollution Prevention Plan to supplement the Owner's Stormwater Pollution Prevention Plan (SWPPP) as contained in the drawings. The plan shall be in strict compliance with the MDOT Specification Section 208, National Pollutant Discharge Elimination System (NPDES) permit issued or approved by the U.S. Environmental Protection Agency (EPA) pursuant to 40 CFR part 122.6. The plan shall address all measures to dispose of, control, or prevent the discharge of solid, hazardous and sanitary wastes to the water of the U.S. The plan shall include procedures to control offsite tracking of soil by vehicles and construction equipment and procedures for cleanup and reporting of non-storm water discharges such as contaminated groundwater or accidental spills.

The Contractor shall obtain the necessary NPDES and Soil Erosion and Sedimentation Control permit from the Wayne County Department of Public Services-Environmental Services Group and any other required permits unless specified otherwise.

The Contractor shall also be required to submit a written documentation that all required permits have been obtained to the Engineer prior to startup of construction activities.

CONSTRUCTION REQUIREMENTS

102-3.1 General. In the event of conflict between these requirements and pollution control laws, rules, or regulations of other federal, state, or local agencies, the more restrictive laws, rules, or regulations shall apply.

The Engineer shall be responsible for assuring compliance to the extent that construction practices, construction operations, and construction work are involved.

METHOD OF MEASUREMENT

Temporary erosion and pollution control work required will be performed as scheduled or directed by the Engineer and per MDOT Specification Section 208 standards.

102-4.10 Soil Erosion Inspection Fees. Permit Fees shall be measured by the amount the actual cost of all permit fees required for this project. The Contractor must follow the requirements of the City of Detroit Construction Services Agreement – Attachment A, for reimbursement of direct costs associated with the permit and inspection fees.

102-4.11 Dust Control. Measures employed for dust control and prevention of air pollution shall be considered incidental to other items of this contract and no separate measurement or payment will be made.

102-4.12 Control of work performed for protection of construction areas outside the construction limits, such as borrow and waste areas, haul roads, equipment and material storage sites, and temporary plant sites, will not be measured and paid for directly but shall be considered as a subsidiary obligation of the Contractor.

BASIS OF PAYMENT

102-5.10 Soil Erosion Inspection Fees. Payment for soil erosion inspection fees will be paid under the allowance outlined in this specification. The Contractor shall pay the Permit and Inspection Fee: Wayne County $0 and shall post the following Performance Deposits: Wayne County $0. Performance Deposit may be a Surety Bond, Irrevocable Letter of Credit, or Certified Check. No separate payment will be made for costs associated with the Performance Deposit. The costs shall be incidental to the work items.

102-5.11 Dust Control. No direct payment shall be made for dust control.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
SX-125-2.1	NPDES and Soil Erosion and Sedimentation Control Permit and Inspection Fee	Allowance (ALLOW)

Where other directed work falls within the specifications for a work item that has a contract price, the units of work shall be measured and paid for at the contract unit price bid for the various items.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Advisory Circulars (AC)

AC 150/5200-33 *Hazardous Wildlife Attractants on or Near Airports*

AC 150/5370-2 *Operational Safety on Airports During Construction*

ASTM International (ASTM)

ASTM D6461 *Standard Specification for Silt Fence Materials*

MDOT Specifications

Section 208 *Soil Erosion and Sedimentation Control*

United States Department of Agriculture (USDA)

FAA/USDA Wildlife Hazard Management at Airports, A Manual for Airport Personnel

END OF ITEM SX-125

ITEM DX-800 Soft Digs

DESCRIPTION

800-1.1 This item shall consist of soft digs as directed by the RPR in accordance with these specifications.

CONSTRUCTION METHODS

800-2.1 Soft digs shall consist of the Contractor providing precise horizontal and vertical locations of subsurfaces structures or utilities obtained by exposing and measuring subsurface utilities at the approximate locations shown on the contract documents. The actual location of the soft dig over subsurface structures or utilities shall be determined by using surface geophysical methods to trace the horizontal alignment of underground infrastructure to establish the location to expose said structures or utilities. After the soft dig location is determined by the Contractor, the location shall be reviewed with the RPR prior to performing the soft dig.

The work shall be completed in accordance with CI/ASCE 38-02, "Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data". This Standard Guideline defines utility quality levels and the specific means and methods for each quality level. However, the provisions in this specification take precedence over CI/ASCE 38-02.

The work shall be performed by a Subsurface Utility Engineering (SUE) provider. SUE is a branch of engineering practice that involves managing certain risks associated with utility mapping at appropriate quality levels, utility coordination, utility relocation design and coordination, utility condition assessment, communication of utility data to concerned parties, utility relocation cost estimates, implementation of utility accommodation policies, and utility design. The SUE provider shall be duly licensed as a professional engineer and shall have 10 years minimum experience in SUE. Contractor to submit experience.

The SUE provider shall own all equipment and shall not subcontract any of the work except professional surveying and pavement removal where applicable. The SUE provider's equipment shall include ground penetrating radar (GPR), single and multi-frequency pipe and cable locating equipment, acoustical pipe locators, pipe cameras, sondes, and truck mounted air-based vacuum excavation equipment, SerVac, VacMasters or equal (hydrovac systems shall not be allowed).

All soft digs performed, regardless of the size of the utility, shall locate the center point of the utility. The utility's width and/or diameter shall be measured. The location, top of elevation, and pipe inverts shall be determined by survey. This will be counted as one soft dig. Subsurface conditions that prevent the direct exposure of the utility will not eliminate or reduce payment for soft digs completed. The utility's measurements and surveyed location, elevation and inverts shall be given to the RPR.

METHOD OF MEASUREMENT

800-3.1 **Soft Digs**. Shall be measured by each unit completed and accepted by the RPR.

800-3.2 **Unforeseen Utilities**. Shall be provided as an allowance for additional utility / drainage conflicts not identified in the plan documents. This item shall compensate the Contractor for the costs associated with performing work, as directed by the Department and not otherwise shown, related to existing utility or drainage modifications either as required by utility service company or mitigation of unforeseen conflicts or impacts for the conflicted utility. Work may include, but is not limited to, providing utility access, resolution of utility or drainage conflicts, drainage or grading modifications, subsurface investigation, existing ductbank proofing, test pits, and facility utility costs beyond substantial completion.

BASIS OF PAYMENT

800-4.1 **Soft Digs.** Payment shall be made at the contract unit price per each for soft digs, which prices and payments shall be full compensation for furnishing and placing all material and for all labor, equipment, tools, and incidentals necessary to complete the work prescribed in this item.

800-4.2 **Unforeseen Utilities.** The Contractor must receive written notice from the Department to proceed with the work. The work will be paid for per allowance for explored conflicting utility conflicts.

Payment will be made under the following items:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
DX-800-4.1	Soft Digs - Bid Alt 1	Per Each (EA)
DX-800-4.2	Unforeseen Utilities	Allowance (ALLOW)
DX-800-4.3	Unforeseen Utilities – Bid Alt 1	Allowance (ALLOW)

END OF ITEM DX-800

ITEM P-153 Controlled Low-Strength Material (CLSM)

DESCRIPTION

153-1.1 This item shall consist of furnishing, transporting, and placing a controlled low-strength material (CLSM) as flowable backfill in trenches or at other locations shown on the plans or as directed by the Engineer.

MATERIALS

153-2.1 **Materials.**

(a) **Portland Cement.** Cement shall conform to the requirements of ASTM C150, Type I or II .

(b) **Fly ash.** Fly ash shall conform to ASTM C618, Class C or F.

(c) **Fine aggregate (Sand).** Fine aggregate shall conform to the requirements of ASTM C33 except for aggregate gradation. Any aggregate gradation which produces the specified performance characteristics of the CLSM and meets the following requirements, will be accepted, except as follows.

Sieve Size	Percent Passing by weight
3/4 inch	100
No. 200	0 - 12

(d) **Water.** Water used in mixing or curing shall be from potable water sources. Other sources shall be tested in accordance with ASTM C1602 prior to use.

MIX DESIGN

153-3.1 **Proportions.** The Contractor shall submit, to the Engineer, a mix design including the proportions and source of aggregate, fly ash, cement, water, and approved admixtures. No CLSM mixture shall be produced for payment until the Engineer has given written approval of the proportions. The proportions shall be prepared by a laboratory and shall remain in effect for the duration of the project. The proportions shall establish a single percentage or weight for aggregate, fly ash, cement, water, and any admixtures proposed. Laboratory costs are incidental to this item.

(a) **Compressive strength.** CLSM shall be designed to achieve a 28-day compressive strength of 100 to 200 psi when tested in accordance with ASTM D4832, with no significant strength gain after 28 days.

(b) **Consistency.** Design CLSM to achieve a consistency that will produce an approximate 8-inch diameter circular-type spread without segregation. CLSM consistency shall be determined per ASTM D6103.

CONSTRUCTION METHODS

153-4.1 **Placement.**

(a) **Placement.** CLSM may be placed by any reasonable means from the mixing unit into the space to be filled. Agitation is required during transportation and waiting time. Placement shall be performed so structures or pipes are not displaced from their final position and intrusion of CLSM into unwanted areas is avoided. The material shall be brought up uniformly to the fill line shown on the plans or as directed by the Engineer. Each placement of CLSM shall be as continuous an operation as possible. If CLSM is placed in more than one lift, the base lift shall be free of surface water and loose foreign material prior to placement of the next lift.

(b) **Contractor Quality Control**. The Contractor shall collect all batch tickets to verify the CLSM delivered to the project conforms to the mix design. The Contractor shall verify daily that the CLSM is consistent with 153-3.1a and 153-3.1b. Adjustments shall be made as necessary to the proportions and materials as needed. The Contractor shall provide all batch tickets to the ENGINEER.

(c) **Limitations of placement.** CLSM shall not be placed on frozen ground. Mixing and placing may begin when the air or ground temperature is at least 35°F and rising. Mixing and placement shall stop when the air temperature is 40°F and falling or when the anticipated air or ground temperature will be 35°F or less in the 24-hour period following proposed placement. At the time of placement, CLSM shall have a temperature of at least 40°F.

153-4.2 **Curing and protection**

(a) **Curing.** The air in contact with the CLSM shall be maintained at temperatures above freezing for a minimum of 72 hours. If the CLSM is subjected to temperatures below 32°F, the material may be rejected by the ENGINEER if damage to the material is observed.

(b) **Protection.** The CLSM shall not be subject to loads and shall remain undisturbed by construction activities for a period of 48 hours or until a compressive strength of 15 psi is obtained. The Contractor shall be responsible for providing evidence to the Engineer that the material has reached the desired strength. Acceptable evidence shall be based upon compressive tests made in accordance with paragraph 153-3.1a.

153-4.3 **Quality Assurance (QA) Acceptance.** CLSM QA acceptance shall be based upon batch tickets provided by the Contractor to the Engineer to confirm that the delivered material conforms to the mix design.

METHOD OF MEASUREMENT

153-5.1 **Measurement.** No measurement for payment shall be made for CLSM.

BASIS OF PAYMENT

153-6.1 **Payment.** CLSM shall be incidental to the pay items that it is being applied.

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)

ASTM C33	Standard Specification for Concrete Aggregates
ASTM C150	Standard Specification for Portland Cement
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C595	Standard Specification for Blended Hydraulic Cements
ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D4832	Standard Test Method for Preparation and Testing of Controlled Low-Strength Material (CLSM) Test Cylinders
ASTM D6103	Flow Consistency of Controlled Low Strength Material (CLSM)

END OF ITEM P-153

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Item L-108 Underground Power Cable for Airports

DESCRIPTION

108-1.1 This item shall consist of furnishing and installing power cables that are direct buried and furnishing and/or installing power cables within conduit or duct banks per these specifications at the locations shown on the plans. It includes excavation and backfill of trench for direct-buried cables only. Also included are the installation of counterpoise wires, ground wires, ground rods and connections, cable splicing, cable marking, cable testing, and all incidentals necessary to place the cable in operating condition as a completed unit to the satisfaction of the Engineer. This item shall not include the installation of duct banks or conduit, trenching and backfilling for duct banks or conduit, or furnishing or installation of cable for FAA owned/operated facilities.

EQUIPMENT AND MATERIALS

108-2.1 General.

a. Airport lighting equipment and materials covered by advisory circulars (AC) shall be approved under the Airport Lighting Equipment Certification Program per AC 150/5345-53, current version.

b. All other equipment and materials covered by other referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification, when requested by the Engineer.

c. Manufacturer's certifications shall not relieve the Contractor of the responsibility to provide materials per these specifications. Materials supplied and/or installed that do not comply with these specifications shall be removed (when directed by the Engineer) and replaced with materials that comply with these specifications at the Contractor's cost.

d. All materials and equipment used to construct this item shall be submitted to the Engineer for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Submittal data shall be presented in a clear, precise and thorough manner. Original catalog sheets are preferred. Photocopies are acceptable provided they are as good a quality as the original. Clearly and boldly mark each copy to identify products or models applicable to this project. Indicate all optional equipment and delete any non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment to which they apply on each submittal sheet. Markings shall be made bold and clear with arrows or circles (highlighting is not acceptable). The Contractor is solely responsible for delays in the project that may accrue directly or indirectly from late submissions or resubmissions of submittals.

e. The data submitted shall be sufficient, in the opinion of the Engineer, to determine compliance with the plans and specifications. The Contractor's submittals shall be electronically submitted in pdf format. The Engineer reserves the right to reject any and all equipment, materials, or procedures that do not meet the system design and the standards and codes, specified in this document.

f. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for at least twelve (12) months from the date of final acceptance by

the Owner. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner. The Contractor shall maintain a minimum insulation resistance in accordance with paragraph 108-3.10e with isolation transformers connected in new circuits and new segments of existing circuits through the end of the contract warranty period when tested in accordance with AC 150/5340-26, *Maintenance Airport Visual Aid Facilities*, paragraph 5.1.3.1, Insulation Resistance Test.

108-2.2 Cable. Underground cable for airfield lighting facilities (runway and taxiway lights and signs) shall conform to the requirements of AC 150/5345-7, Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits latest edition. Conductors for use on 6.6 ampere primary airfield lighting series circuits shall be single conductor, seven strand, #8 American wire gauge (AWG), L-824 Type C, 5,000 volts, non-shielded, with cross-linked polyethylene insulation. L-824 conductors for use on the L-830 secondary of airfield lighting series circuits shall be sized in accordance with the manufacturer's recommendations. All other conductors shall comply with FAA and National Electric Code (NEC) requirements. Conductor sizes noted above shall not apply to leads furnished by manufacturers on airfield lighting transformers and fixtures.

Wire for electrical circuits up to 600 volts shall comply with Specification L-824 and/or Commercial Item Description A-A-59544A and shall be type THWN-2, 75°C for installation in conduit and RHW-2, 75°C for direct burial installations. Conductors for parallel (voltage) circuits shall be type and size and installed in accordance with NFPA-70, National Electrical Code.

Unless noted otherwise, all 600-volt and less non-airfield lighting conductor sizes are based on a 75°C, THWN-2, 600-volt insulation, copper conductors, not more than three single insulated conductors, in raceway, in free air. The conduit/duct sizes are based on the use of THWN-2, 600-volt insulated conductors. The Contractor shall make the necessary increase in conduit/duct sizes for other types of wire insulation. In no case shall the conduit/duct size be reduced. The minimum power circuit wire size shall be #12 AWG.

Conductor sizes may have been adjusted due to voltage drop or other engineering considerations. Equipment provided by the Contractor shall be capable of accepting the quantity and sizes of conductors shown in the Contract Documents. All conductors, pigtails, cable step-down adapters, cable step-up adapters, terminal blocks and splicing materials necessary to complete the cable termination/splice shall be considered incidental to the respective pay items provided.

Cable type, size, number of conductors, strand and service voltage shall be as specified in the Contract Document.

108-2.3 Bare copper wire (counterpoise, bare copper wire ground and ground rods). Wire for counterpoise or ground installations for airfield lighting systems shall be No. 6 AWG bare solid copper wire for counterpoise and/or No. 6 AWG insulated stranded for grounding bond wire per ASTM B3 and ASTM B8, and shall be bare copper wire. For voltage powered circuits, the equipment grounding conductor shall comply with NEC Article 250.

Ground rods shall be copper. The ground rods shall be of the length and diameter specified on the plans, but in no case be less than 10 feet long and 3/4 inch in diameter.

108-2.4 Cable connections. In-line connections or splices of underground primary cables shall be of the type called for on the plans, and shall be one of the types listed below. No separate payment will be made for cable connections.

a. The cast splice. A cast splice, employing a plastic mold and using epoxy resin equivalent to that manufactured by 3M™ Company, "Scotchcast" Kit No. 82-B, or an approved equivalent, used for potting the splice is acceptable.

b. The field-attached plug-in splice. Field attached plug-in splices shall be installed as shown on the plans. The Contractor shall determine the outside diameter of the cable to be spliced and furnish appropriately sized connector kits and/or adapters. Tape or heat shrink tubing with integral sealant shall be in accordance with the manufacturer's requirements. Primary Connector Kits manufactured by Amerace, "Super Kit", Integro "Complete Kit", or approved equal is acceptable.

c. The factory-molded plug-in splice. Specification for L-823 Connectors, Factory-Molded to Individual Conductors, is acceptable.

d. The taped or heat-shrink splice. Taped splices employing field-applied rubber, or synthetic rubber tape covered with plastic tape is acceptable. The rubber tape should meet the requirements of ASTM D4388 and the plastic tape should comply with Military Specification MIL-I-24391 or Commercial Item Description A-A-55809. Heat shrinkable tubing shall be heavy-wall, self-sealing tubing rated for the voltage of the wire being spliced and suitable for direct-buried installations. The tubing shall be factory coated with a thermoplastic adhesive-sealant that will adhere to the insulation of the wire being spliced forming a moisture- and dirt-proof seal. Additionally, heat shrinkable tubing for multi-conductor cables, shielded cables, and armored cables shall be factory kits that are designed for the application. Heat shrinkable tubing and tubing kits shall be manufactured by Tyco Electronics/ Raychem Corporation, Energy Division, or approved equivalent.

In all the above cases, connections of cable conductors shall be made using crimp connectors using a crimping tool designed to make a complete crimp before the tool can be removed. All L-823/L-824 splices and terminations shall be made per the manufacturer's recommendations and listings.

All connections of counterpoise, grounding conductors and ground rods shall be made by the exothermic process or approved equivalent, except that a light base ground clamp connector shall be used for attachment to the light base. All exothermic connections shall be made per the manufacturer's recommendations and listings.

108-2.5 Splicer qualifications. Every airfield lighting cable splicer shall be qualified in making airport cable splices and terminations on cables rated at or above 5,000 volts AC. The Contractor shall submit to the Engineer proof of the qualifications of each proposed cable splicer for the airport cable type and voltage level to be worked on. Cable splicing/terminating personnel shall have a minimum of three (3) years continuous experience in terminating/splicing medium voltage cable.

108-2.6 Concrete. Concrete shall be proportioned, placed, and cured per state department of transportation structural concrete with minimum 25% Type F fly ash, and a minimum allowable compressive strength of 4,000 psi.

108-2.7 Flowable backfill. Flowable material used to backfill trenches for power cable trenches shall conform to the requirements of Item P-153, Controlled Low Strength Material.

108-2.8 Cable identification tags. Cable identification tags shall be made from a non-corrosive material with the circuit identification stamped or etched onto the tag. The tags shall be of the type as detailed on the plans.

108-2.9 Tape. Electrical tapes shall be Scotch™ Electrical Tapes –Scotch™ 88 (1-1/2 inch wide) and Scotch™ 130C® linerless rubber splicing tape (2-inch wide), as manufactured by the Minnesota Mining and Manufacturing Company (3M™), or an approved equivalent.

108-2.10 Electrical coating. Electrical coating shall be Scotchkote™ as manufactured by 3M™, or an approved equivalent.

108-2.11 Existing circuits. Whenever the scope of work requires connection to an existing circuit, the existing circuit's insulation resistance shall be tested, in the presence of the Engineer. The test shall be performed per this item and prior to any activity that will affect the respective circuit. The Contractor shall record the results on forms acceptable to the Engineer. When the work affecting the circuit is complete, the circuit's insulation resistance shall be checked again, in the presence of the Engineer. The Contractor shall record the results on forms acceptable to the Engineer. The second reading shall be equal to or greater than the first reading or the Contractor shall make the necessary repairs to the existing circuit to bring the second reading above the first reading. All repair costs including a complete replacement of the L-823 connectors, L-830 transformers and L-824 cable, if necessary, shall be borne by the Contractor. All test results shall be submitted in the Operation and Maintenance (O&M) Manual.

108-2.12 Detectable warning tape. Plastic, detectable, American Public Works Association (APWA) Red (electrical power lines, cables, conduit and lighting cable) with continuous legend tape shall be polyethylene film with a metalized foil core and shall be 3-6 inches wide. Detectable tape is incidental to the respective bid item. Detectable warning tape for communication cables shall be orange. Detectable warning tape color code shall comply with the APWA Uniform Color Code.

CONSTRUCTION METHODS

108-3.1 General. The Contractor shall install the specified cable at the approximate locations indicated on the plans. Unless otherwise shown on the plans, all cable required to cross under pavements expected to carry aircraft loads shall be installed in concrete encased duct banks. Cable shall be run without splices, from fixture to fixture.

Cable connections between lights will be permitted only at the light locations for connecting the underground cable to the primary leads of the individual isolation transformers. The Contractor shall be responsible for providing cable in continuous lengths for home runs or other long cable runs without connections unless otherwise authorized in writing by the Engineer or shown on the plans.

In addition to connectors being installed at individual isolation transformers, L-823 cable connectors for maintenance and test points shall be installed at locations shown on the plans. Cable circuit identification markers shall be installed on both sides of the L-823 connectors installed and on both sides of slack loops where a future connector would be installed.

Provide not less than 3 feet of cable slack on each side of all connections, isolation transformers, light units, and at points where cable is connected to field equipment. Where provisions must be made for testing or for future above grade connections, provide enough slack to allow the cable to be extended at least one foot vertically above the top of the access structure. This requirement also applies where primary cable passes through empty light bases, junction boxes, and access structures to allow for future connections, or as designated by the Engineer.

Primary airfield lighting cables installed shall have cable circuit identification markers attached on both sides of each L-823 connector and on each airport lighting cable entering or leaving cable access points, such as manholes, hand holes, pull boxes, junction boxes, etc. Markers shall be of sufficient length for imprinting the cable circuit identification legend on one line, using letters not less than 1/4 inch in size. The cable circuit identification shall match the circuits noted on the construction plans.

108-3.2 Installation in duct banks or conduits. This item includes the installation of the cable in duct banks or conduit per the following paragraphs. The maximum number and voltage ratings of cables installed in each single duct or conduit, and the current-carrying capacity of each cable shall be per the latest version of the National Electric Code, or the code of the local agency or authority having jurisdiction.

The Contractor shall make no connections or splices of any kind in cables installed in conduits or duct banks.

Unless otherwise designated in the plans, where ducts are in tiers, use the lowest ducts to receive the cable first, with spare ducts left in the upper levels. Check duct routes prior to construction to obtain assurance that the shortest routes are selected and that any potential interference is avoided.

Duct banks or conduits shall be installed as a separate item per Item L-110, Airport Underground Electrical Duct Banks and Conduit. The Contractor shall run a mandrel through duct banks or conduit prior to installation of cable to ensure that the duct bank or conduit is open, continuous and clear of debris. The mandrel size shall be compatible with the conduit size. The Contractor shall swab out all conduits/ducts and clean light bases, manholes, etc., interiors immediately prior to pulling cable. Once cleaned and swabbed, the light bases and all accessible points of entry to the duct/conduit system shall be kept closed except when installing cables. Cleaning of ducts, light bases, manholes, etc., is incidental to the pay item of the item being cleaned. All raceway systems left open, after initial cleaning, for any reason shall be re-cleaned at the Contractor's expense. The Contractor shall verify existing ducts proposed for use in this project as clear and open. The Contractor shall notify the Engineer of any blockage in the existing ducts.

The cable shall be installed in a manner that prevents harmful stretching of the conductor, damage to the insulation, or damage to the outer protective covering. The ends of all cables shall be sealed with moisture-seal tape providing moisture-tight mechanical protection with minimum bulk, or alternately, heat shrinkable tubing before pulling into the conduit and it shall be left sealed until connections are made. Where more than one cable is to be installed in a conduit, all cable shall be pulled in the conduit at the same time. The pulling of a cable through duct banks or conduits may be accomplished by hand winch or power winch with the use of cable grips or pulling eyes. Maximum pulling tensions shall not exceed the cable manufacturer's recommendations. A non-hardening cable-pulling lubricant recommended for the type of cable being installed shall be used where required.

The Contractor shall submit the recommended pulling tension values to the Engineer prior to any cable installation. If required by the Engineer, pulling tension values for cable pulls shall be monitored by a dynamometer in the presence of the Engineer. Cable pull tensions shall be recorded by the Contractor and reviewed by the Engineer. Cables exceeding the maximum allowable pulling tension values shall be removed and replaced by the Contractor at the Contractor's expense.

The manufacturer's minimum bend radius or NEC requirements (whichever is more restrictive) shall apply. Cable installation, handling and storage shall be per manufacturer's recommendations. During cold weather, particular attention shall be paid to the manufacturer's minimum installation temperature. Cable shall not be installed when the temperature is at or below the manufacturer's minimum installation temperature. At the Contractor's option, the Contractor may submit a plan, for review by the Engineer, for heated storage of the cable and maintenance of an acceptable cable temperature during installation when temperatures are below the manufacturer's minimum cable installation temperature.

Cable shall not be dragged across base can or manhole edges, pavement or earth. When cable must be coiled, lay cable out on a canvas tarp or use other appropriate means to prevent abrasion to the cable jacket.

108-3.3 Installation of direct-buried cable in trenches. Unless otherwise specified, the Contractor shall not use a cable plow for installing the cable. Cable shall be unreeled uniformly in place alongside or in the trench and shall be carefully placed along the bottom of the trench. The cable shall not be unreeled and pulled into the trench from one end. Slack cable sufficient to provide strain relief shall be placed in the trench in a series of S curves. Sharp bends or kinks in the cable shall not be permitted.

Where cables must cross over each other, a minimum of 3 inches vertical displacement shall be provided with the topmost cable depth at or below the minimum required depth below finished grade.

a. Trenching. Where turf is well established and the sod can be removed, it shall be carefully stripped and properly stored. Trenches for cables may be excavated manually or with mechanical trenching equipment. Walls of trenches shall be essentially vertical so that a minimum of surface is disturbed. Graders shall not be used to excavate the trench with their blades. The bottom surface of trenches shall be essentially smooth and free from coarse aggregate. Unless otherwise specified, cable trenches shall be excavated to a minimum depth of 18 inches below finished grade per NEC Table 300.5, except as follows:

- When off the airport or crossing under a roadway or driveway, the minimum depth shall be 36 inches unless otherwise specified.
- Minimum cable depth when crossing under a railroad track, shall be 42 inches unless otherwise specified.

The Contractor shall excavate all cable trenches to a width not less than 6 inches. Unless otherwise specified on the plans, all cables in the same location and running in the same general direction shall be installed in the same trench.

When rock is encountered, the rock shall be removed to a depth of at least 3 inches below the required cable depth and it shall be replaced with bedding material of earth or sand containing no mineral aggregate particles that would be retained on a 1/4-inch sieve. Flowable backfill material may alternatively be used.

Duct bank or conduit markers temporarily removed for trench excavations shall be replaced as required.

It is the Contractor's responsibility to locate existing utilities within the work area prior to excavation. Where existing active cables cross proposed installations, the Contractor shall ensure that these cables are adequately protected. Where crossings are unavoidable, no splices will be allowed in the existing cables, except as specified on the plans. Installation of new cable where such crossings must occur shall proceed as follows:

(1) Existing cables shall be located manually. Unearthed cables shall be inspected to assure absolutely no damage has occurred.

(2) Trenching, etc., in cable areas shall then proceed, with approval of the Engineer, with care taken to minimize possible damage or disruption of existing cable, including careful backfilling in area of cable.

In the event that any previously identified cable is damaged during the course of construction, the Contractor shall be responsible for the complete repair or replacement.

b. Backfilling. After the cable has been installed, the trench shall be backfilled. The first layer of backfill in the trench shall encompass all cables; be 3 inches deep, loose measurement; and shall be either earth or sand containing no mineral aggregate particles that would be retained on a 1/4-inch sieve. This layer shall not be compacted. The second layer shall be 5 inches deep, loose measurement, and shall contain no particles that would be retained on a one inch sieve. The remaining third and subsequent layers of backfill shall not exceed 8 inches of loose measurement and be excavated or imported material and shall not contain stone or aggregate larger than 4 inches maximum diameter.

The second and subsequent layers shall be thoroughly tamped and compacted to at least the density of the adjacent material. If the cable is to be installed in locations or areas where other compaction

requirements are specified (under pavements, embankments, etc.) the backfill compaction shall be to a minimum of 100 percent of ASTM D1557.

Trenches shall not contain pools of water during backfilling operations. The trench shall be completely backfilled and tamped level with the adjacent surface, except that when turf is to be established over the trench, the backfilling shall be stopped at an appropriate depth consistent with the type of turfing operation to be accommodated. A proper allowance for settlement shall also be provided. Any excess excavated material shall be removed and disposed of per the plans and specifications.

Underground electrical warning (caution) tape shall be installed in the trench above all direct-buried cable. Contractor shall submit a sample of the proposed warning tape for acceptance by the Engineer. If not shown on the plans, the warning tape shall be located 6 inches above the direct-buried cable or the counterpoise wire if present. A 3-6 inch wide polyethylene film detectable tape, with a metalized foil core, shall be installed above all direct buried cable or counterpoise. The tape shall be of the color and have a continuous legend as indicated on the plans. The tape shall be installed 8 inches minimum below finished grade.

c. Restoration. Following restoration of all trenching near airport movement surfaces, the Contractor shall visually inspect the area for foreign object debris (FOD) and remove any that is found. Where soil and sod has been removed, it shall be replaced as soon as possible after the backfilling is completed. All areas disturbed by work shall be restored to its original condition. The restoration shall include the sodding as shown on the plans. The Contractor shall be held responsible for maintaining all disturbed surfaces and replacements until final acceptance. When trenching is through paved areas, restoration shall be equal to existing conditions. If the cable is to be installed in locations or areas where other compaction requirements are specified (under pavements, embankments, etc.) the backfill compaction shall be to a minimum of 100 percent of ASTM D1557. Restoration shall be considered incidental to the pay item of which it is a component part.

108-3.4 Cable markers for direct-buried cable. The location of direct buried circuits shall be marked by a concrete slab marker, 2 feet square and 4-6 inch thick, extending approximately one inch above the surface. Each cable run from a line of lights and signs to the equipment vault shall be marked at approximately every 200 feet along the cable run, with an additional marker at each change of direction of cable run. All other direct-buried cable shall be marked in the same manner. Cable markers shall be installed directly above the cable. The Contractor shall impress the word “CABLE” and directional arrows on each cable marking slab. The letters shall be approximately 4 inches high and 3 inches wide, with width of stroke 1/2 inch and 1/4 inch deep. Stencils shall be used for cable marker lettering; no hand lettering shall be permitted.

At the location of each underground cable connection/splice, except at lighting units, or isolation transformers, a concrete marker slab shall be installed to mark the location of the connection/splice. The Contractor shall impress the word “SPLICE” on each slab. The Contractor also shall impress additional circuit identification symbols on each slab as directed by the Engineer. All cable markers and splice markers shall be painted international orange. Paint shall be specifically manufactured for uncured exterior concrete. After placement, all cable or splice markers shall be given one coat of high-visibility aviation orange paint as approved by the Engineer. Furnishing and installation of cable markers is incidental to the respective cable pay item.

108-3.5 Splicing. Connections of the type shown on the plans shall be made by experienced personnel regularly engaged in this type of work and shall be made as follows:

a. Cast splices. These shall be made by using crimp connectors for jointing conductors. Molds shall be assembled, and the compound shall be mixed and poured per the manufacturer’s instructions and to the satisfaction of the Engineer.

b. Field-attached plug-in splices. These shall be assembled per the manufacturer's instructions. These splices shall be made by plugging directly into mating connectors. The joint where the connectors come together shall be finished by one of the following methods: (1) wrapped with at least one layer of rubber or synthetic rubber tape and one layer of plastic tape, one-half lapped, extending at least 1-1/2 inches (38 mm) on each side of the joint (2) Covered with heat shrinkable tubing with integral sealant extending at least 1-1/2 inches on each side of the joint or (3) On connector kits equipped with water seal flap; roll-over water seal flap to sealing position on mating connector.

c. Factory-molded plug-in splices. These shall be made by plugging directly into mating connectors. The joint where the connectors come together shall be finished by one of the following methods: (1) Wrapped with at least one layer of rubber or synthetic rubber tape and one layer of plastic tape, one-half lapped, extending at least 1-1/2 inches on each side of the joint. (2) Covered with heat shrinkable tubing with integral sealant extending at least 1-1/2 inches on each side of the joint. or (3) On connector kits so equipped with water seal flap; roll-over water seal flap to sealing position on mating connector.

d. Taped or heat-shrink splices. A taped splice shall be made in the following manner:

Bring the cables to their final position and cut so that the conductors will butt. Remove insulation and jacket allowing for bare conductor of proper length to fit compression sleeve connector with 1/4 inch of bare conductor on each side of the connector. Prior to splicing, the two ends of the cable insulation shall be penciled using a tool designed specifically for this purpose and for cable size and type. Do not use emery paper on splicing operation since it contains metallic particles. The copper conductors shall be thoroughly cleaned. Join the conductors by inserting them equidistant into the compression connection sleeve. Crimp conductors firmly in place with crimping tool that requires a complete crimp before tool can be removed. Test the crimped connection by pulling on the cable. Scrape the insulation to assure that the entire surface over which the tape will be applied (plus 3 inches on each end) is clean. After scraping, wipe the entire area with a clean lint-free cloth. Do not use solvents.

Apply high-voltage rubber tape one-half lapped over bare conductor. This tape should be tensioned as recommended by the manufacturer. Voids in the connector area may be eliminated by highly elongating the tape, stretching it just short of its breaking point. The manufacturer's recommendation for stretching tape during splicing shall be followed. Always attempt to exactly half-lap to produce a uniform buildup. Continue buildup to 1-1/2 times cable diameter over the body of the splice with ends tapered a distance of approximately one inch over the original jacket. Cover rubber tape with two layers of vinyl pressure-sensitive tape one-half lapped. Do not use glyptol or lacquer over vinyl tape as they react as solvents to the tape. No further cable covering or splice boxes are required.

Heat shrinkable tubing shall be installed following manufacturer's instructions. Direct flame heating shall not be permitted unless recommended by the manufacturer. Cable surfaces within the limits of the heat-shrink application shall be clean and free of contaminates prior to application.

e. Assembly. Surfaces of equipment or conductors being terminated or connected shall be prepared in accordance with industry standard practice and manufacturer's recommendations. All surfaces to be connected shall be thoroughly cleaned to remove all dirt, grease, oxides, nonconductive films, or other foreign material. Paints and other nonconductive coatings shall be removed to expose base metal. Clean all surfaces at least 1/4 inch beyond all sides of the larger bonded area on all mating surfaces. Use a joint compound suitable for the materials used in the connection. Repair painted/coated surface to original condition after completing the connection.

108-3.6 Bare counterpoise wire installation for lightning protection and grounding. If shown on the plans or included in the job specifications, bare solid #6 AWG copper counterpoise wire shall be installed for lightning protection of the underground cables. The Engineer shall select one of two methods of

lightning protection for the airfield lighting circuit based upon sound engineering practice and lightning strike density.

a. Equipotential. The counterpoise size is as shown on the plans. The equipotential method is applicable to all airfield lighting systems; i.e. runway, taxiway, apron – touchdown zone, centerline, edge, threshold and approach lighting systems. The equipotential method is also successfully applied to provide lightning protection for power, signal and communication systems. The light bases, counterpoise, etc – all components - are bonded together and bonded to the vault power system ground loop/electrode.

Counterpoise wire shall be installed in the same trench for the entire length of buried cable, conduits and duct banks that are installed to contain airfield cables. The counterpoise is centered over the cable/conduit/duct to be protected.

The counterpoise conductor shall be installed no less than 8 inches minimum or 12 inches mm) maximum above the raceway or cable to be protected, except as permitted below:

(1) The minimum counterpoise conductor height above the raceway or cable to be protected shall be permitted to be adjusted subject to coordination with the airfield lighting and pavement designs.

(2) The counterpoise conductor height above the protected raceway(s) or cable(s) shall be calculated to ensure that the raceway or cable is within a 45-degree area of protection, (45 degrees on each side of vertical creating a 90 degree angle).

The counterpoise conductor shall be bonded to each metallic light base, mounting stake, and metallic airfield lighting component.

All metallic airfield lighting components in the field circuit on the output side of the constant current regulator (CCR) or other power source shall be bonded to the airfield lighting counterpoise system.

All components rise and fall at the same potential; with no potential difference, no damaging arcing and no damaging current flow.

See AC 150/5340-30, Design and Installation Details for Airport Visual Aids and NFPA 780, Standard for the Installation of Lightning Protection Systems, Chapter 11, for a detailed description of the Equipotential Method of lightning protection.

Reference FAA STD-019E, Lightning and Surge Protection, Grounding Bonding and Shielding Requirements for Facilities and Electronic Equipment, Part 4.1.1.7.

c. Common Installation requirements. When a metallic light base is used, the grounding electrode shall be bonded to the metallic light base or mounting stake with a No. 6 AWG bare, annealed or soft drawn, solid copper conductor.

When a nonmetallic light base is used, the grounding electrode shall be bonded to the metallic light fixture or metallic base plate with a No. 6 AWG bare, annealed or soft drawn, solid copper conductor.

Grounding electrodes may be rods, ground dissipation plates, radials, or other electrodes listed in the NFPA 70 (NEC) or NFPA 780.

Where raceway is installed by the directional bore, jack and bore, or other drilling method, the counterpoise conductor shall be permitted to be installed concurrently with the directional bore, jack and bore, or other drilling method raceway, external to the raceway or sleeve.

The counterpoise wire shall also be exothermically welded to ground rods installed as shown on the plans but not more than 500 feet apart around the entire circuit. The counterpoise system shall be continuous and terminate at the transformer vault or at the power source. It shall be securely attached to the vault or equipment external ground ring or other made electrode-grounding system. The connections shall be made as shown on the plans and in the specifications.

Where an existing airfield lighting system is being extended or modified, the new counterpoise conductors shall be interconnected to existing counterpoise conductors at each intersection of the new and existing airfield lighting counterpoise systems.

d. Parallel Voltage Systems. Provide grounding and bonding in accordance with NFPA 70, National Electrical Code.

108-3.7 Counterpoise installation above multiple conduits and duct banks. Counterpoise wires shall be installed above multiple conduits/duct banks for airfield lighting cables, with the intent being to provide a complete area of protection over the airfield lighting cables. When multiple conduits and/or duct banks for airfield cable are installed in the same trench, the number and location of counterpoise wires above the conduits shall be adequate to provide a complete area of protection measured 45 degrees each side of vertical.

Where duct banks pass under pavement to be constructed in the project, the counterpoise shall be placed above the duct bank. Reference details on the construction plans.

108-3.8 Counterpoise installation at existing duct banks. When airfield lighting cables are indicated on the plans to be routed through existing duct banks, the new counterpoise wiring shall be terminated at ground rods at each end of the existing duct bank where the cables being protected enter and exit the duct bank. The new counterpoise conductor shall be bonded to the existing counterpoise system.

108-3.9 Exothermic bonding. Bonding of counterpoise wire shall be by the exothermic welding process or equivalent method accepted by the Engineer. Only personnel experienced in and regularly engaged in this type of work shall make these connections.

Contractor shall demonstrate to the satisfaction of the Engineer, the welding kits, materials and procedures to be used for welded connections prior to any installations in the field. The installations shall comply with the manufacturer's recommendations and the following:

a. All slag shall be removed from welds.

b. Using an exothermic weld to bond the counterpoise to a lug on a galvanized light base is not recommended unless the base has been specially modified. Consult the manufacturer's installation directions for proper methods of bonding copper wire to the light base. See AC 150/5340-30 for galvanized light base exception.

c. If called for in the plans, all buried copper and weld material at weld connections shall be thoroughly coated with 6 mm of 3M™ Scotchkote™, or approved equivalent, or coated with coal tar Bitumastic® material to prevent surface exposure to corrosive soil or moisture.

108-3.10 Testing. The Contractor shall furnish all necessary equipment and appliances for testing the airport electrical systems and underground cable circuits before and after installation. The Contractor shall perform all tests in the presence of the Engineer. The Contractor shall demonstrate the electrical characteristics to the satisfaction of the Engineer. All costs for testing are incidental to the respective item being tested. For phased projects, the tests must be completed by phase. The Contractor must maintain the test results throughout the entire project as well as during the warranty period that meet the following:

a. Earth resistance testing methods shall be submitted to the Engineer for approval. Earth resistance testing results shall be recorded on an approved form and testing shall be performed in the presence of the Engineer. All such testing shall be at the sole expense of the Contractor.

b. Should the counterpoise or ground grid conductors be damaged or suspected of being damaged by construction activities the Contractor shall test the conductors for continuity with a low resistance ohmmeter. The conductors shall be isolated such that no parallel path exists and tested for continuity. The

Engineer shall approve of the test method selected. All such testing shall be at the sole expense of the Contractor.

After installation, the Contractor shall test and demonstrate to the satisfaction of the Engineer the following:

c. That all affected lighting power and control circuits (existing and new) are continuous and free from short circuits.

d. That all affected circuits (existing and new) are free from unspecified grounds.

e. That the insulation resistance to ground of all new non-grounded high voltage series circuits or cable segments is not less than 500 megohms. Verify continuity of all series airfield lighting circuits prior to energization.

f. That the insulation resistance to ground of all new non-grounded conductors of new multiple circuits or circuit segments is not less than 100 megohms.

g. That all affected circuits (existing and new) are properly connected per applicable wiring diagrams.

h. That all affected circuits (existing and new) are operable. Tests shall be conducted that include operating each control not less than 10 times and the continuous operation of each lighting and power circuit for not less than 1/2 hour.

i. That the impedance to ground of each ground rod does not exceed **25** ohms prior to establishing connections to other ground electrodes. The fall-of-potential ground impedance test shall be used, as described by American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE) Standard 81, to verify this requirement. As an alternate, clamp-on style ground impedance test meters may be used to satisfy the impedance testing requirement. Test equipment and its calibration sheets shall be submitted for review and approval by the Engineer prior to performing the testing.

Two copies of tabulated results of all cable tests performed shall be supplied by the Contractor to the Engineer. Where connecting new cable to existing cable, insulation resistance tests shall be performed on the new cable prior to connection to the existing circuit.

There are no approved “repair” procedures for items that have failed testing other than complete replacement.

METHOD OF MEASUREMENT

108-4.1 Trenching shall be measured by the linear feet of trench, including the excavation, backfill, and restoration, completed, measured as excavated, and accepted as satisfactory. When specified, separate measurement shall be made for trenches of various specified widths.

108-4.2 Cable or counterpoise wire installed in trench, duct bank or conduit shall be measured by the number of linear feet installed and grounding connectors, and trench marking tape ready for operation, and accepted as satisfactory. Separate measurement shall be made for each cable or counterpoise wire installed in trench, duct bank or conduit. The measurement for this item `shall` include additional quantities required for slack.

108-4.3 No separate payment will be made for ground rods.

BASIS OF PAYMENT

108-5.1 Payment will be made at the contract unit price for trenching, cable and bare counterpoise wire installed in trench (direct-buried), or cable and equipment ground installed in duct bank or conduit, in place by the Contractor and accepted by the Engineer. This price shall be full compensation for furnishing all materials and for all preparation and installation of these materials, and for all labor, equipment, tools, and incidentals, including ground rods and ground connectors and trench marking tape, necessary to complete this item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
L-108-5.1	No. 6 AWG, Solid, Bare Copper Counterpoise Wire, Installed Above the Duct Bank or Conduit, Including Connections/Terminations	Linear Foot (LF)
L-108-5.2	FAA No. 1/0 AWG, Solid, Bare Copper Counterpoise Wire, Installed Above the Duct Bank or Conduit, Including Connections/Terminations - Bid Alt 1	Linear Foot (LF)
L-108-5.3	FAA 2 PAIR #19 Shielded Control Cable, Inst. In Duct or Conduit – Bid Alt 1	Linear Foot (LF)
L-108-5.4	No. 6 AWG, Solid, Bare Copper Counterpoise Wire, Installed Above the Duct Bank or Conduit, Including Connections/Terminations - Bid Alt 1	Linear Foot (LF)

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Advisory Circulars (AC)

AC 150/5340-26	Maintenance of Airport Visual Aid Facilities
AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-7	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
AC 150/5345-26	Specification for L-823 Plug and Receptacle, Cable Connectors
AC 150/5345-53	Airport Lighting Equipment Certification Program

Commercial Item Description

A-A-59544A	Cable and Wire, Electrical (Power, Fixed Installation)
A-A-55809	Insulation Tape, Electrical, Pressure-Sensitive Adhesive, Plastic

ASTM International (ASTM)

ASTM B3	Standard Specification for Soft or Annealed Copper Wire
ASTM B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM B33	Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes
ASTM D4388	Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes

Mil Spec

MIL-PRF-23586F	Performance Specification: Sealing Compound (with Accelerator), Silicone Rubber, Electrical
MIL-I-24391	Insulation Tape, Electrical, Plastic, Pressure Sensitive

National Fire Protection Association (NFPA)

NFPA-70	National Electrical Code (NEC)
NFPA-780	Standard for the Installation of Lightning Protection Systems

American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE)

ANSI/IEEE STD 81	IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

Federal Aviation Administration Standard

FAA STD-019E	Lightning and Surge Protection, Grounding Bonding and Shielding Requirements for Facilities and Electronic Equipment

END OF ITEM L-108

Item L-109 Airport Transformer Vault and Vault Equipment

DESCRIPTION

109-1.1 This item shall consist of modifying an airport transformer vault or a prefabricated metal housing per these specifications and per the design and dimensions shown in the plans. This work shall also include the installation of conduits in the floor and foundation, painting and lighting of the vault or metal housing, and the furnishing of all incidentals that are necessary to produce a completed unit. Included as a separate part under this item or as a separate item where an existing vault is to be used shall be the furnishing of all vault equipment, wiring, electrical buses, cable, conduit, potheads, and grounding systems. This work shall also include the painting of equipment and conduit; the marking and labeling of equipment and the labeling or tagging of wires; the testing of the installation; and the furnishing of all incidentals necessary to place it in operating condition as a completed unit to the satisfaction of the RPR.

EQUIPMENT AND MATERIALS

109-2.1 General.

a. Airport lighting equipment and materials covered by advisory circulars (AC) shall be certified in AC 150/5345-53, Airport Lighting Equipment Certification Program (ALECP) and listed in the ALECP Addendum.

b. All other equipment and materials covered by other referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification when requested by the RPR.

c. Manufacturer's certifications shall not relieve the Contractor of the responsibility to provide materials per these specifications. Materials supplied and/or installed that do not comply with these specifications shall be removed (when directed by the RPR) and replaced with materials that comply with these specifications at the Contractor's cost.

d. All materials and equipment used to construct this item shall be submitted to the RPR for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Submittal data shall be presented in a clear, precise and thorough manner. Original catalog sheets are preferred. Photocopies are acceptable provided they are as good a quality as the original. Clearly and boldly mark each copy to identify products or models applicable to this project. Indicate all optional equipment and delete any non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment to which they apply on each submittal sheet. Markings shall be made bold and clear with arrows or circles (highlighting is not acceptable). The Contractor is solely responsible for delays in the project that may accrue directly or indirectly from late submissions or resubmissions of submittals.

e. The data submitted shall be sufficient, in the opinion of the RPR, to determine compliance with the plans and specifications. The Contractor's submittals shall be provided in electronic pdf format, tabbed by specification section. The RPR reserves the right to reject any and all equipment, materials or procedures that do not meet the system design and the standards and codes, specified in this document.

f. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for a period of at least twelve (12) months from final acceptance by the Owner. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner.

CONSTRUCTION OF VAULT AND PREFABRICATED METAL HOUSING

109-3.1 Electrical vault building. The electrical vault building must comply with NEC Article 110.31, Enclosure for Electrical Installations, Item (A) Electrical Vaults. Construct the building of materials having adequate structural strength for the conditions and installed location, has a minimum fire rating of two or three hours as determined by the authority having jurisdiction (AHJ), and is bullet resistant to minimum UL 752 Level 4.

109-3.2 Concrete. Not Used.

109-3.3 Precast concrete structures. Not Used.

109-3.4 Reinforcing steel. Not Used.

109-3.5 Brick. Not Used.

109-3.6 Rigid steel conduit. Rigid steel conduit and fittings shall be per Underwriters Laboratories Standards 6 and 514B.

109-3.7 Plastic Conduit and fittings. Plastic Conduit and fittings shall conform to the requirements of UL-651 and UL-654 schedule 40 polyvinyl chloride (PVC) suitable for use above or below ground.

109-3.8 Lighting. Not Used.

109-3.9 Outlets. Not Used.

109-3.10 Switches. Not Used.

109-3.11 Paint. Not Used.

109-3.12 Ground bus. Not Used.

109-3.13 Square duct. Duct shall be square similar to that manufactured by the Square D Company (or equivalent), or the Trumbull Electric Manufacturing Company (or equivalent). The entire front of the duct on each section shall consist of hinged or removable cover for ready access to the interior. The cross-section of the duct shall be not less than 4 × 4 inch (100 × 100 mm) except where otherwise shown in the plans.

109-3.14 Ground rods. Not Used.

109-3.15 Vault prefabricated metal housing. Not Used.

109-3.16 FAA-approved equipment. Certain items of airport lighting equipment installed in vaults are covered by individual ACs listed below:

AC 150/5345-3	Specification for L-821, Panels for Remote Control of Airport Lighting
AC 150/5345-5	Circuit Selector Switch
AC 150/5345-7	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
AC 150/5345-10	Specification for Constant Current Regulators and Regulator Monitors

AC 150/5345-13	Specification for L-841 Auxiliary Relay Cabinet Assembly for Pilot Control of Airport Lighting Circuits.
AC 150/5345-49	Specification for L-854, Radio Control Equipment
AC 150/5345-56	Specification for L-890 Airport Lighting Control and Monitoring System (ALCMS)

109-3.17 Other electrical equipment. Distribution transformers, oil switches, cutouts, relays, terminal blocks, transfer relays, circuit breakers, and all other regularly used commercial items of electrical equipment not covered by FAA equipment specifications and ACs shall conform to the applicable rulings and standards of the Institute of Electrical and Electronic Engineers (IEEE) or the National Electrical Manufacturers Association (NEMA). When specified, test reports from a testing laboratory indicating that the equipment meets the specifications shall be supplied. In all cases, equipment shall be new and a first-grade product. This equipment shall be supplied in the quantities required for the specific project and shall incorporate the electrical and mechanical characteristics specified in the proposal and plans. Equipment selected and installed by the Contractor shall maintain the interrupting current rating of the existing systems or specified rating whichever is greater.

109-3.18 Wire. Wire (in conduit) rated up to 5,000 volts shall be per AC 150/5345-7, Specification for L-824 Underground Electrical Cables for Airport Lighting Circuits. For ratings up to 600 volts, moisture and heat resistant thermoplastic wire conforming to Commercial Item Description A-A-59544A Type THWN-2 shall be used. The wires shall be of the type, size, number of conductors, and voltage shown in the plans or in the proposal.

a. Control circuits. Unless otherwise indicated on the plans, wire shall be not less than No. 12 American wire gauge (AWG) and shall be insulated for 600 volts. If telephone control cable is specified, No. 19 AWG telephone cable per ANSI/Insulated Cable Engineers Association (ICEA) S-85-625 specifications shall be used.

b. Power circuits.

(1) 600 volts maximum – Wire shall be No. 6 AWG or larger and insulated for at least 600 volts.

(2) 3,000 volts maximum – Wire shall be No. 6 AWG or larger and insulated for at least 3,000 volts.

(3) Over 3,000 volts-Wire shall be No. 6 AWG or larger and insulated for at least the circuit voltage.

109-3.19 Short circuit / coordination / device evaluation / arc flash analysis. The Contractor shall, based upon the equipment provided, include as a part of the submittal process the electrical system "Short Circuit / Coordination / Device evaluation / Arc Flash Analysis". The analysis shall be performed by the equipment manufacturer and submitted in a written report. The analysis shall be signed and sealed by a registered professional Engineer from the state in which the project is located. The analysis shall comply with NFPA-70E and IEEE 1584.

The analysis will include: one line diagrams, short circuit analysis, coordination analysis, equipment evaluation, arc flash analysis and arc flash labels containing at a minimum, equipment name, voltage/current rating, available incident energy and flash protection boundary.

The selected firms field service Engineer shall perform data gathering for analysis completion and device settings, perform device setting as recommended by the analysis and will furnish and install the arc flash labels. The components worst case incident energy will be considered the available arc flash energy at that specific point in the system. Submit three written copies and one electronic copy of the report.

INSTALLATION OF EQUIPMENT IN VAULT OR PREFABRICATED METAL HOUSING

109-5.1 General. The Contractor shall furnish, install, and connect all equipment, equipment accessories, conduit, cables, wires, buses, grounds, and support necessary to ensure a complete and operable electrical distribution center for the airport lighting system as specified herein and shown in the plans. When specified, an emergency power supply and transfer switch shall be provided and installed.

The equipment installation and mounting shall comply with the requirements of the National Electrical Code and local code agency having jurisdiction. All electrical work shall comply with the NEC and local code agency having jurisdiction including the separation of under 600V work from 5,000V work."

109-5.2 Power supply equipment. Transformers, regulators, booster transformers, and other power supply equipment items shall be furnished and installed at the location shown in the plans or as directed by the RPR. The power supply equipment shall be set on steel "H" sections, "I" beams, channels, or concrete blocks to provide a minimum space of 1-1/2 inch (38 mm) between the equipment and the floor. The equipment shall be placed so as not to obstruct the oil-sampling plugs of the oil-filled units; and name-plates shall, so far as possible, not be obscured.

If specified in the plans and specifications, equipment for an alternate power source or an emergency power generator shall be furnished and installed. The alternate power supply installation shall include all equipment, accessories, an automatic changeover switch, and all necessary wiring and connections. The emergency power generator set shall be the size and type specified.

109-5.3 Switchgear and panels. Oil switches, fused cutouts, relays, transfer switches, panels, panel boards, and other similar items shall be furnished and installed at the location shown in the plans or as directed by the RPR. Wall or ceiling mounted items shall be attached to the wall or ceiling with galvanized bolts of not less than 3/8-inch (9 mm) diameter engaging metal expansion shields or anchors in masonry or concrete vaults.

109-5.4 Duct and conduit. The Contractor shall furnish and install square-type exposed metallic ducts with hinged covers for the control circuits in the vault. These shall be mounted along the walls behind all floor-mounted equipment and immediately below all wall-mounted equipment. The hinged covers shall be placed to open from the front side with the hinges at the front bottom.

Wall brackets for square ducts shall be installed at all joints 2 feet (60 cm) or more apart with intermediate brackets as specified. Conduit shall be used between square ducts and equipment or between different items of equipment when the equipment is designed for conduit connection. When the equipment is not designed for conduit connection, conductors shall enter the square-type control duct through insulating bushings in the duct or on the conduit risers.

109-5.5 Wiring and connections. The Contractor shall make all necessary electrical connections in the vault per the wiring diagrams furnished and as directed by the RPR. In wiring to the terminal blocks, the Contractor shall leave sufficient extra length on each control lead to make future changes in connections at the terminal block. This shall be accomplished by running each control lead the longest way around the box to the proper terminal. Leads shall be neatly laced in place.

109-5.6 Marking and labeling. All equipment, control wires, terminal blocks, etc., shall be tagged, marked, or labeled as specified below:

a. Wire identification. The Contractor shall furnish and install self-sticking wire labels or identifying tags on all control wires at the point where they connect to the control equipment or to the terminal blocks. Wire labels, if used, shall be of the self-sticking preprinted type and of the manufacturer's

recommended size for the wire involved. Identification -markings designated in the plans shall be followed. Tags, if used, shall be of fiber not less than 3/4 inch (19 mm) in diameter and not less than 1/32 inch (1 mm) thick. Identification markings designated in the plans shall be stamped on tags by means of small tool dies. Each tag shall be securely tied to the proper wire by a nonmetallic cord.

b. Labels. The Contractor shall stencil identifying labels on the cases of regulators, breakers, and distribution and control relay cases with white oil paint as designated by the RPR. The letters and numerals shall be not less than one inch (25 mm) in height and shall be of proportionate width. The Contractor shall also mark the correct circuit designations per the wiring diagram on the terminal marking strips, which are a part of each terminal block.

METHOD OF MEASUREMENT

109-6.1 All vault modifications shall be measured by lump sum under this item. The pay item shall include all equipment installed, connected and accepted as a complete unit ready for operation within an existing vault.

BASIS OF PAYMENT

109-7.1 Payment will be made at the contract unit price for the lump sum of completed and accepted vault modifications. This price shall be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
L-109-7.1	Vault Modifications	Lump Sum (LS)

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Advisory Circulars (AC)

AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-3	Specification for L-821, Panels for Remote Control of Airport Lighting
AC 150/5345-5	Circuit Selector Switch
AC 150/5345-7	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
AC 150/5345-10	Specification for Constant Current Regulators and Regulator Monitors
AC 150/5345-13	Specification for L-841 Auxiliary Relay Cabinet Assembly for Pilot Control of Airport Lighting Circuits
AC 150/5345-49	Specification L-854, Radio Control Equipment;
AC 150/5345-53	Airport Lighting Equipment Certification Program

American National Standards Institute / Insulated Cable Engineers Association (ANSI/ICEA)

ANSI/ICEA S-85-625	Standard for Telecommunications Cable Aircore, Polyolefin Insulated, Copper Conductor Technical Requirements

ASTM International (ASTM)

ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM C62	Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C90	Standard Specification for Loadbearing Concrete Masonry Units
ASTM D2823	Standard Specification for Asphalt Roof Coatings, Asbestos Containing
ASTM D4479	Standard Specification for Asphalt Roof Coatings – Asbestos-Free

Commercial Item Description (CID)

A-A 59544	Cable and Wire, Electrical (Power, Fixed Installation)

Institute of Electrical and Electronic Engineers (IEEE)

IEEE 1584	Guide for Performing Arc-Flash Hazard Calculations

Master Painter's Institute (MPI)

MPI Reference #9	Alkyd, Exterior, Gloss (MPI Gloss Level 6)

Underwriters Laboratories (UL)

UL Standard 6	Electrical Rigid Metal Conduit – Steel
UL Standard 514B	Conduit, Tubing, and Cable Fittings
UL Standard 514C	Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL Standard 651	Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL Standard 651A	Type EB and A Rigid PVC Conduit and HDPE Conduit

National Fire Protection Association (NFPA)

NFPA-70	National Electrical Code (NEC)
NFPA-70E	Standard for Electrical Safety in the Workplace
NFPA-780	Standard for the Installation of Lightning Protection Systems

END OF ITEM L-109

Item L-110 Airport Underground Electrical Duct Banks and Conduits

DESCRIPTION

110-1.1 This item shall consist of underground electrical conduits and duct banks (single or multiple conduits encased in concrete or buried in sand) installed per this specification at the locations and per the dimensions, designs, and details shown on the plans. This item shall include furnishing and installing of all underground electrical duct banks and individual and multiple underground conduits . It shall also include all turfing trenching, backfilling, removal, and restoration of any paved or turfed areas; concrete encasement, mandrelling, pulling lines, duct markers, plugging of conduits, and the testing of the installation as a completed system ready for installation of cables per the plans and specifications. This item shall also include furnishing and installing conduits and all incidentals for providing positive drainage of the system. Verification of existing ducts is incidental to the pay items provided in this specification.

EQUIPMENT AND MATERIALS

110-2.1 General.

a. All equipment and materials covered by referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification when requested by the Engineer.

b. Manufacturer's certifications shall not relieve the Contractor of the responsibility to provide materials per these specifications and acceptable to the Engineer. Materials supplied and/or installed that do not comply with these specifications shall be removed, when directed by the Engineer and replaced with materials, that comply with these specifications, at the Contractor's cost.

c. All materials and equipment used to construct this item shall be submitted to the Engineer for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Submittal data shall be presented in a clear, precise and thorough manner. Original catalog sheets are preferred. Photocopies are acceptable provided they are as good a quality as the original. Clearly and boldly mark each copy to identify products or models applicable to this project. Indicate all optional equipment and delete non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment for which they apply on each submittal sheet. Markings shall be made bold and clear with arrows or circles (highlighting is not acceptable). The Contractor is solely responsible for delays in project that accrue directly or indirectly from late submissions or resubmissions of submittals.

d. The data submitted shall be sufficient, in the opinion of the Engineer, to determine compliance with the plans and specifications. The Contractor's submittals shall be electronically submitted in pdf format, tabbed by specification section. The Engineer reserves the right to reject any and all equipment, materials or procedures that do not meet the system design and the standards and codes specified in this document.

e. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for a period of at least twelve (12) months from final acceptance by

the Owner. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner.

110-2.2 Steel conduit. Rigid galvanized steel (RGS) conduit and fittings shall be hot dipped galvanized inside and out and conform to the requirements of Underwriters Laboratories Standards 6, 514B, and 1242. All RGS conduits or RGS elbows installed below grade, in concrete, permanently wet locations or other similar environments shall be painted with a 10-mil thick coat of asphaltum sealer or shall have a factory-bonded polyvinyl chloride (PVC) cover. Any exposed galvanizing or steel shall be coated with 10 mils of asphaltum sealer. When using PVC coated RGS conduit, care shall be exercised not to damage the factory PVC coating. Damaged PVC coating shall be repaired per the manufacturer's written instructions. In lieu of PVC coated RGS, corrosion wrap tape shall be permitted to be used where RGS is in contact with direct earth."

110-2.3 Plastic conduit. Plastic conduit and fittings-shall conform to the following requirements:

- UL 514B covers W-C-1094-Conduit fittings all types, classes 1 thru 3 and 6 thru 10.
- UL 514C covers W-C-1094- all types, Class 5 junction box and cover in plastic (PVC).
- UL 651 covers W-C-1094-Rigid PVC Conduit, types I and II, Class 4.
- UL 651A covers W-C-1094-Rigid PVC Conduit and high-density polyethylene (HDPE) Conduit type III and Class 4.

Underwriters Laboratories Standards UL-651 and Article 352 of the current National Electrical Code shall be one of the following, as shown on the plans:

a. Type I–Schedule 40 and Schedule 80 PVC suitable for underground use either direct-buried or encased in concrete.

b. Type II–Schedule 40 PVC suitable for either above ground or underground use.

c. Type III – Schedule 80 PVC suitable for either above ground or underground use either direct-buried or encased in concrete.

d. Type III –HDPE pipe, minimum standard dimensional ratio (SDR) 11, suitable for placement with directional boring under pavement.

The type of solvent cement shall be as recommended by the conduit/fitting manufacturer.

110-2.4 Split conduit. Split conduit shall be pre-manufactured for the intended purpose and shall be made of steel or plastic.

110-2.5 Conduit spacers. Conduit spacers shall be prefabricated interlocking units manufactured for the intended purpose. They shall be of double wall construction made of high grade, high density polyethylene complete with interlocking cap and base pads. They shall be designed to accept No. 4 reinforcing bars installed vertically.

110-2.6 Concrete. Concrete shall be proportioned, placed, and cured per state department of transportation structural concrete with minimum 25% Type F fly ash, and a minimum allowable compressive strength of 4,000 psi.

110-2.7 Precast concrete structures. Precast concrete structures shall be furnished by a plant meeting National Precast Concrete Association Plant Certification Program or another Engineer approved third party certification program. Precast concrete structures shall conform to ASTM C478.

110-2.8 Flowable backfill. Flowable material used to back fill conduit and duct bank trenches shall conform to the requirements of Item P-153, Controlled Low Strength Material.

110-2.9 Detectable warning tape. Plastic, detectable, American Public Works Association (APWA) red (electrical power lines, cables, conduit and lighting cable), orange (telephone/fiber optic cabling) with continuous legend magnetic tape shall be polyethylene film with a metallized foil core and shall be 3-6 inches wide. Detectable tape is incidental to the respective bid item.

CONSTRUCTION METHODS

110-3.1 General. The Contractor shall install underground duct banks and conduits at the approximate locations indicated on the plans. The Engineer shall indicate specific locations as the work progresses, if required to differ from the plans. Duct banks and conduits shall be of the size, material, and type indicated on the plans or specifications. Where no size is indicated on the plans or in the specifications, conduits shall be not less than 2 inches inside diameter or comply with the National Electrical Code based on cable to be installed, whichever is larger. All duct bank and conduit lines shall be laid so as to grade toward access points and duct or conduit ends for drainage. Unless shown otherwise on the plans, grades shall be at least 3 inches per 100 feet. On runs where it is not practicable to maintain the grade all one way, the duct bank and conduit lines shall be graded from the center in both directions toward access points or conduit ends, with a drain into the storm drainage system. Pockets or traps where moisture may accumulate shall be avoided. Under pavement, the top of the duct bank shall not be less than 18 inches below the subgrade; in other locations, the top of the duct bank or underground conduit shall be no less than 18 inches below finished grade.

The Contractor shall mandrel each individual conduit whether the conduit is direct-buried or part of a duct bank. An iron-shod mandrel, not more than 1/4 inch smaller than the bore of the conduit shall be pulled or pushed through each conduit. The mandrel shall have a leather or rubber gasket slightly larger than the conduit hole.

The Contractor shall swab out all conduits/ducts and clean base can, manhole, pull boxes, etc., interiors immediately prior to pulling cable. Once cleaned and swabbed the light bases, manholes, pull boxes, etc., and all accessible points of entry to the duct/conduit system shall be kept closed except when installing cables. Cleaning of ducts, base cans, manholes, etc., is incidental to the pay item of the item being cleaned. All raceway systems left open, after initial cleaning, for any reason shall be recleaned at the Contractor's expense. All accessible points shall be kept closed when not installing cable. The Contractor shall verify existing ducts proposed for use in this project as clear and open. The Contractor shall notify the ENGINEER of any blockage in the existing ducts.

For pulling the permanent wiring, each individual conduit, whether the conduit is direct-buried or part of a duct bank, shall be provided with a 200-pound test polypropylene pull rope. The ends shall be secured and sufficient length shall be left in access points to prevent it from slipping back into the conduit. Where spare conduits are installed, as indicated on the plans, the open ends shall be plugged with removable tapered plugs, designed for this purpose.

All conduits shall be securely fastened in place during construction and shall be plugged to prevent contaminants from entering the conduits. Any conduit section having a defective joint shall not be installed. Ducts shall be supported and spaced apart using approved spacers at intervals not to exceed 5 feet.

Unless otherwise shown on the plans, concrete encased duct banks shall be used when crossing under pavements expected to carry aircraft loads, such as runways, taxiways, taxilanes, ramps and aprons. When under paved shoulders and other paved areas, conduit and duct banks shall be encased using flowable fill for protection.

All conduits within concrete encasement of the duct banks shall terminate with female ends for ease in current and future use. Install factory plugs in all unused ends. Do not cover the ends or plugs with concrete.

Where turf is well established and the sod can be removed, it shall be carefully stripped and properly stored.

Trenches for conduits and duct banks may be excavated manually or with mechanical trenching equipment unless in pavement, in which case they shall be excavated with mechanical trenching equipment. Walls of trenches shall be essentially vertical so that a minimum of shoulder surface is disturbed. Blades of graders shall not be used to excavate the trench.

When rock is encountered, the rock shall be removed to a depth of at least 3 inches below the required conduit or duct bank depth and it shall be replaced with bedding material of earth or sand containing no mineral aggregate particles that would be retained on a 1/4-inch sieve. Flowable backfill may alternatively be used

Underground electrical warning (Caution) tape shall be installed in the trench above all underground duct banks and conduits in unpaved areas. Contractor shall submit a sample of the proposed warning tape for approval by the Engineer. If not shown on the plans, the warning tape shall be located 6 inches above the duct/conduit or the counterpoise wire if present.

Joints in plastic conduit shall be prepared per the manufacturer's recommendations for the particular type of conduit. Plastic conduit shall be prepared by application of a plastic cleaner and brushing a plastic solvent on the outside of the conduit ends and on the inside of the couplings. The conduit fitting shall then be slipped together with a quick one-quarter turn twist to set the joint tightly. Where more than one conduit is placed in a single trench, or in duct banks, joints in the conduit shall be staggered a minimum of 2 feet.

Changes in direction of runs exceeding 10 degrees, either vertical or horizontal, shall be accomplished using manufactured sweep bends.

Whether or not specifically indicated on the drawings, where the soil encountered at established duct bank grade is an unsuitable material, as determined by the Engineer, the unsuitable material shall be removed per MDOT 205 and replaced with suitable material. Additional duct bank supports shall be installed, as approved by the Engineer.

All excavation shall be unclassified and shall be considered incidental to Item L-110. Dewatering necessary for duct installation, and erosion per federal, state, and local requirements is incidental to Item L-110.

Unless otherwise specified, excavated materials that are deemed by the Engineer to be unsuitable for use in backfill or embankments shall be removed and disposed of offsite.

Any excess excavation shall be filled with suitable material approved by the Engineer and compacted per MDOT 205.

It is the Contractor's responsibility to locate existing utilities within the work area prior to excavation. Where existing active cables cross proposed installations, the Contractor shall ensure that these cables are adequately protected. Where crossings are unavoidable, no splices will be allowed in the existing cables, except as specified on the plans. Installation of new cable where such crossings must occur shall proceed as follows:

a. Existing cables shall be located manually. Unearthed cables shall be inspected to assure absolutely no damage has occurred

b. Trenching, etc., in cable areas shall then proceed with approval of the Engineer, with care taken to minimize possible damage or disruption of existing cable, including careful backfilling in area of cable.

In the event that any previously identified cable is damaged during the course of construction, the Contractor shall be responsible for the complete repair.

110-3.2 Duct banks. Unless otherwise shown in the plans, duct banks shall be installed so that the top of the concrete envelope is not less than 18 inches below the bottom of the base or stabilized base course layers where installed under runways, taxiways, aprons, or other paved areas, and not less than 18 inches below finished grade where installed in unpaved areas.

Unless otherwise shown on the plans, duct banks under paved areas shall extend at least 3 feet beyond the edges of the pavement or 3 feet beyond any under drains that may be installed alongside the paved area. Trenches for duct banks shall be opened the complete length before concrete is placed so that if any obstructions are encountered, provisions can be made to avoid them. Unless otherwise shown on the plans, all duct banks shall be placed on a layer of concrete not less than 3 inches thick prior to its initial set. The Contractor shall space the conduits not less than 3 inches apart (measured from outside wall to outside wall). All such multiple conduits shall be placed using conduit spacers applicable to the type of conduit. As the conduit laying progresses, concrete shall be placed around and on top of the conduits not less than 3 inches thick unless otherwise shown on the plans. All conduits shall terminate with female ends for ease of access in current and future use. Install factory plugs in all unused ends. Do not cover the ends or plugs with concrete.

Conduits forming the duct bank shall be installed using conduit spacers. No. 4 reinforcing bars shall be driven vertically into the soil a minimum of 6 inches to anchor the assembly into the earth prior to placing the concrete encasement. For this purpose, the spacers shall be fastened down with locking collars attached to the vertical bars. Spacers shall be installed at 5-foot intervals. Spacers shall be in the proper sizes and configurations to fit the conduits. Locking collars and spacers shall be submitted to the Engineer for review prior to use.

When specified, the Contractor shall reinforce the bottom side and top of encasements with steel reinforcing mesh or fabric or other approved metal reinforcement. When directed, the Contractor shall supply additional supports where the ground is soft and boggy, where ducts cross under roadways, or where shown on the plans. Under such conditions, the complete duct structure shall be supported on reinforced concrete footings, piers, or piles located at approximately 5-foot intervals.

All pavement surfaces that are to have ducts installed therein shall be neatly saw cut to form a vertical face. All excavation shall be included in the contract with price for the duct.

Install a plastic, detectable, color as noted, 3 to 6 inches wide tape, 8 inches minimum below grade above all underground conduit or duct lines not installed under pavement. Utilize the 3-inch wide tape only for single conduit runs. Utilize the 6-inch wide tape for multiple conduits and duct banks. For duct banks equal to or greater than 24 inches in width, utilize more than one tape for sufficient coverage and identification of the duct bank as required.

When existing cables are to be placed in split duct, encased in concrete, the cable shall be carefully located and exposed by hand tools. Prior to being placed in duct, the Engineer shall be notified so that he may inspect the cable and determine that it is in good condition. Where required, split duct shall be installed as shown on the drawings or as required by the Engineer.

110-3.3 Conduits without concrete encasement. Trenches for single-conduit lines shall be not less than 6 inches nor more than 12 inches wide. The trench for 2 or more conduits installed at the same level shall be proportionately wider. Trench bottoms for conduits without concrete encasement shall be made to conform accurately to grade so as to provide uniform support for the conduit along its entire length.

Unless otherwise shown on the plans, a layer of fine earth material, at least 4 inches thick (loose measurement) shall be placed in the bottom of the trench as bedding for the conduit. The bedding material shall consist of soft dirt, sand or other fine fill, and it shall contain no particles that would be retained on a 1/4-inch sieve. The bedding material shall be tamped until firm. Flowable backfill may alternatively be used.

Unless otherwise shown on plans, conduits shall be installed so that the tops of all conduits within the Airport's secured area where trespassing is prohibited are at least 18 inches below the finished grade. Conduits outside the Airport's secured area shall be installed so that the tops of the conduits are at least 24 inches below the finished grade per National Electric Code (NEC), Table 300.5.

When two or more individual conduits intended to carry conductors of equivalent voltage insulation rating are installed in the same trench without concrete encasement, they shall be spaced not less than 3 inches apart (measured from outside wall to outside wall) in a horizontal direction and not less than 6 inches apart in a vertical direction. Where two or more individual conduits intended to carry conductors of differing voltage insulation rating are installed in the same trench without concrete encasement, they shall be placed not less than 3 inches apart (measured from outside wall to outside wall) in a horizontal direction and lot less than 6 inches apart in a vertical direction.

Trenches shall be opened the complete length between normal termination points before conduit is installed so that if any unforeseen obstructions are encountered, proper provisions can be made to avoid them.

Conduits shall be installed using conduit spacers. No. 4 reinforcing bars shall be driven vertically into the soil a minimum of 6 inches to anchor the assembly into the earth while backfilling. For this purpose, the spacers shall be fastened down with locking collars attached to the vertical bars. Spacers shall be installed at 5-foot intervals. Spacers shall be in the proper sizes and configurations to fit the conduits. Locking collars and spacers shall be submitted to the Engineer for review prior to use.

110-3.4 Markers. The location of each end and of each change of direction of conduits and duct banks shall be marked by a concrete slab marker 2 feet square and 4 - 6 inches thick extending approximately one inch above the surface. The markers shall also be located directly above the ends of all conduits or duct banks, except where they terminate in a junction/access structure or building. Each cable or duct run from a line of lights and signs to the equipment vault must be marked at approximately every 200 feet along the cable or duct run, with an additional marker at each change of direction of cable or duct run.

The Contractor shall impress the word "DUCT" or "CONDUIT" on each marker slab. Impression of letters shall be done in a manner, approved by the Engineer, for a neat, professional appearance. All letters and words must be neatly stenciled. After placement, all markers shall be given one coat of high-visibility orange paint, as approved by the Engineer. The Contractor shall also impress on the slab the number and size of conduits beneath the marker along with all other necessary information as determined by the Engineer. The letters shall be 4 inches high and 3 inches wide with width of stroke 1/2 inch and 1/4 inch deep or as large as the available space permits. Furnishing and installation of duct markers is incidental to the respective duct pay item.

110-3.5 Backfilling for conduits. For conduits, 8 inches of sand, soft earth, or other fine fill (loose measurement) shall be placed around the conduits ducts and carefully tamped around and over them with hand tampers. The remaining trench shall then be backfilled and compacted per MDOT 205 except that material used for back fill shall be select material not larger than 4 inches in diameter.

Flowable backfill may alternatively be used.

Trenches shall not contain pools of water during back filling operations.

The trench shall be completely backfilled and tamped level with the adjacent surface; except that, where sod is to be placed over the trench, the backfilling shall be stopped at a depth equal to the thickness of the sod to be used, with proper allowance for settlement.

Any excess excavated material shall be removed and disposed of per instructions issued by the Engineer.

110-3.6 Backfilling for duct banks. After the concrete has cured, the remaining trench shall be backfilled and compacted per MDOT 205 "Roadway Earthwork" except that the material used for backfill shall be select material not larger than 4 inches in diameter. In addition to the requirements of MDOT 205, where duct banks are installed under pavement, one moisture/density test per lift shall be made for each 250 linear feet of duct bank or one work period's construction, whichever is less.

Flowable backfill may alternatively be used.

Trenches shall not contain pools of water during backfilling operations.

The trench shall be completely backfilled and tamped level with the adjacent surface; except that, where sod is to be placed over the trench, the backfilling shall be stopped at a depth equal to the thickness of the sod to be used, with proper allowance for settlement.

Any excess excavated material shall be removed and disposed of per instructions issued by the Engineer.

110-3.7 Restoration. Where sod has been removed, it shall be replaced as soon as possible after the backfilling is completed. All areas disturbed by the work shall be restored to its original condition. The restoration shall include sodding and topsoiling as shown on the plans. The Contractor shall be held responsible for maintaining all disturbed surfaces and replacements until final acceptance. All restoration shall be considered incidental to the respective L-110 pay item. Following restoration of all trenching near airport movement surfaces, the Contractor shall thoroughly visually inspect the area for foreign object debris (FOD), and remove any such FOD that is found. This FOD inspection and removal shall be considered incidental to the pay item of which it is a component part.

110-3.8 Ownership of removed cable. Contractor shall recycle removed cable.

METHOD OF MEASUREMENT

110-4.1 Underground conduits and duct banks shall be measured by the linear feet of conduits and duct banks installed, including encasement, locator tape, trenching and backfill with designated material, and restoration, and for drain lines, the termination at the drainage structure, all measured in place, completed, and accepted. Separate measurement shall be made for the various types and sizes.

BASIS OF PAYMENT

110-5.1 Payment will be made at the contract unit price per linear foot for each type and size of conduit and duct bank completed and accepted, including trench and backfill with the designated material, and, for drain lines, the termination at the drainage structure. This price shall be full compensation for removal and disposal of existing duct banks and conduits as shown on the plans, furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete this item per the provisions and intent of the plans and specifications.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
L-110-5.1	Concrete Encased Electrical Duct Bank, 1 Way 2", Including Trench and Backfill	Linear Foot (LF)
L-110-5.2	Concrete Encased Electrical Duct Bank, 2 Way 2" , Including Trench and Backfill	Linear Foot (LF)
L-110-5.3	1 Way 2" Schedule 40 PVC Conduit, Including Trench and Backfill	Linear Foot (LF)
L-110-5.4	2 Way 2" Schedule 40 PVC Conduit, Including Trench and Backfill	Linear Foot (LF)
L-110-5.5	FAA Disconnect and Removal of Conduit - Bid Alt 1	Linear Foot (LF)
L-110-5.6	FAA 2W-4", Concrete Encased Ductbank, Incl. Trench And Backfill - Bid Alt 1	Linear Foot (LF)
L-110-5.7	Concrete Encased Electrical Duct Bank, 1 Way 2", Including Trench and Backfill - Bid Alt 1	Linear Foot (LF)
L-110-5.8	Concrete Encased Electrical Duct Bank, 2 Way 2" , Including Trench and Backfill - Bid Alt 1	Linear Foot (LF)
L-110-5.9	1 Way 2" Schedule 40 PVC Conduit, Including Trench and Backfill - Bid Alt 1	Linear Foot (LF)
L-110-5.10	2 Way 2" Schedule 40 PVC Conduit, Including Trench and Backfill - Bid Alt 1	Linear Foot (LF)
L-110-5.11	FAA Disconnect and Removal of Conduit - Bid Alt 1 - Bid Alt 1	Linear Foot (LF)

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Advisory Circular (AC)

AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-53	Airport Lighting Equipment Certification Program

ASTM International (ASTM)

ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

National Fire Protection Association (NFPA)

NFPA-70	National Electrical Code (NEC)

Underwriters Laboratories (UL)

UL Standard 6	Electrical Rigid Metal Conduit - Steel
UL Standard 514B	Conduit, Tubing, and Cable Fittings
UL Standard 514C	Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL Standard 1242	Electrical Intermediate Metal Conduit Steel
UL Standard 651	Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings

UL Standard 651A Type EB and A Rigid PVC Conduit and HDPE Conduit

END OF ITEM L-110

Item L-115 Electrical Manholes and Junction Structures

DESCRIPTION

115-1.1 This item shall consist of electrical manholes and junction structures (hand holes, pull boxes, junction cans, etc.) installed per this specification, at the indicated locations and conforming to the lines, grades and dimensions shown on the plans or as required by the RPR. This item shall include the installation of each electrical manhole and/or junction structures with all associated excavation, backfilling, sheeting and bracing, concrete, reinforcing steel, ladders, appurtenances, testing, dewatering and restoration of surfaces to the satisfaction of the RPR.

EQUIPMENT AND MATERIALS

115-2.1 General.

a. All equipment and materials covered by referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification when so requested by the RPR.

b. Manufacturer's certifications shall not relieve the Contractor of the responsibility to provide materials per these specifications. Materials supplied and/or installed that do not comply with these specifications shall be removed (when directed by the RPR) and replaced with materials that comply with these specifications at the Contractor's cost.

c. All materials and equipment used to construct this item shall be submitted to the RPR for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Submittal data shall be presented in a clear, precise and thorough manner. Original catalog sheets are preferred. Photocopies are acceptable provided they are as good a quality as the original. Clearly and boldly mark each copy to identify products or models applicable to this project. Indicate all optional equipment and delete any non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment to which they apply on each submittal sheet. Markings shall be made bold and clear with arrows or circles (highlighting is not acceptable). The Contractor is solely responsible for delays in the project that may accrue directly or indirectly from late submissions or resubmissions of submittals.

d. The data submitted shall be sufficient, in the opinion of the RPR, to determine compliance with the plans and specifications**.** The Contractor's submittals shall be electronically submitted in pdf format, tabbed by specification section. The RPR reserves the right to reject any and all equipment, materials or procedures that do not meet the system design and the standards and codes, specified in this document.

e. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for a period of at least twelve (12) months from the date of final acceptance by the Owner. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner.

115-2.2 Concrete structures. Concrete shall be proportioned, placed, and cured per MDOT 1004. Cast-in-place concrete structures shall be as shown on the plans.

115-2.3 Precast concrete structures. Precast concrete structures shall be furnished by a plant meeting National Precast Concrete Association Plant Certification Program or another engineer approved third party certification program. Provide precast concrete structures where shown on the plans.

Precast concrete structures shall be an approved standard design of the manufacturer. Precast units shall have mortar or bitumastic sealer placed between all joints to make them watertight. The structure shall be designed to withstand 75,000 lb aircraft loads, unless otherwise shown on the plans. Openings or knockouts shall be provided in the structure as detailed on the plans.

Threaded inserts and pulling eyes shall be cast in as shown on the plans.

If the Contractor chooses to propose a different structural design, signed and sealed shop drawings, design calculations, and other information requested by the RPR shall be submitted by the Contractor to allow for a full evaluation by the RPR. The RPR shall review per the process defined in the General Provisions.

115-2.4 Junction boxes. Junction boxes shall be L-867 Class 1 (non-load bearing) or L-868 Class 1 (load bearing) airport light bases that are encased in concrete. The light bases shall have a L-894 blank cover, gasket, and stainless steel hardware. All bolts, studs, nuts, lock washers, and other similar fasteners used for the light fixture assemblies must be fabricated from 316L (equivalent to EN 1.4404), 18-8, 410, or 416 stainless steel. If 18-8, 410, or 416 stainless steel is utilized it shall be passivated and be free from any discoloration. Covers shall be 3/8-inch thickness for L-867 and 3/4-inch thickness for L-868. All junction boxes shall be provided with both internal and external ground lugs.

115-2.5 Mortar. The mortar shall be composed of one part of cement and two parts of mortar sand, by volume. The cement shall be per the requirements in ASTM C150, Type I. The sand shall be per the requirements in ASTM C144. Hydrated lime may be added to the mixture of sand and cement in an amount not to exceed 15% of the weight of cement used. The hydrated lime shall meet the requirements of ASTM C206. Water shall be potable, reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product.

115-2.6 Concrete. Concrete shall be proportioned, placed, and cured per state department of transportation structural concrete with minimum 25% Type F fly ash, and a minimum allowable compressive strength of 4,000 psi (28 MPa).

115-2.7 Frames and covers. The frames shall conform to one of the following requirements:

a. ASTM A48 Gray iron castings

b. ASTM A47 Malleable iron castings

c. ASTM A27 Steel castings

d. ASTM A283, Grade D Structural steel for grates and frames

e. ASTM A536 Ductile iron castings

f. ASTM A897 Austempered ductile iron castings

All castings specified shall withstand a maximum tire pressure of **250** psi and maximum load of **100,000** lbs.

All castings or structural steel units shall conform to the dimensions shown on the plans and shall be designed to support the loadings specified.

Each frame and cover unit shall be provided with fastening members to prevent it from being dislodged by traffic, but which will allow easy removal for access to the structure.

All castings shall be thoroughly cleaned. After fabrication, structural steel units shall be galvanized to meet the requirements of ASTM A123.

Each cover shall have the word “ELECTRIC” or other approved designation cast on it. Each frame and cover shall be as shown on the plans or approved equivalent. No cable notches are required.

Each manhole shall be provided with a “DANGER -- PERMIT-REQUIRED CONFINED SPACE, DO NOT ENTER” safety warning sign as detailed in the Contract Documents and in accordance with OSHA 1910.146 (c)(2).

115-2.8 Ladders. Ladders, if specified, shall be galvanized steel or as shown on the plans.

115-2.9 Reinforcing steel. All reinforcing steel shall be deformed bars of new billet steel meeting the requirements of ASTM A615, Grade 60.

115-2.10 Bedding/special backfill. Bedding or special backfill shall be as shown on the plans.

115-2.11 Flowable backfill. Flowable material used to backfill shall conform to the requirements of Item P-153, Controlled Low Strength Material.

115-2.12 Cable trays. Cable trays shall be of galvanized. Cable trays shall be located as shown on the plans.

115-2.13 Plastic conduit. Plastic conduit shall comply with Item L-110, Airport Underground Electrical Duct Banks and Conduits.

115-2.14 Conduit terminators. Conduit terminators shall be pre-manufactured for the specific purpose and sized as required or as shown on the plans.

115-2.15 Pulling-in irons. Pulling-in irons shall be manufactured with 7/8-inch diameter hot-dipped galvanized steel or stress-relieved carbon steel roping designed for concrete applications (7 strand, 1/2-inch diameter with an ultimate strength of 270,000 psi). Where stress-relieved carbon steel roping is used, a rustproof sleeve shall be installed at the hooking point and all exposed surfaces shall be encapsulated with a polyester coating to prevent corrosion.

115-2.16 Ground rods. Ground rods shall be one piece, copper**.** The ground rods shall be of the length and diameter specified on the plans, but in no case shall they be less than 8 feet long nor less than 5/8 inch in diameter.

CONSTRUCTION METHODS

115-3.1 Unclassified excavation. It is the Contractor’s responsibility to locate existing utilities within the work area prior to excavation. Damage to utility lines, through lack of care in excavating, shall be repaired or replaced to the satisfaction of the RPR without additional expense to the Owner.

The Contractor shall perform excavation for structures and structure footings to the lines and grades or elevations shown on the plans or as staked by the RPR. The excavation shall be of sufficient size to permit the placing of the full width and length of the structure or structure footings shown.

All excavation shall be unclassified and shall be considered incidental to Item L-115. Dewatering necessary for structure installation and erosion per federal, state, and local requirements is incidental to Item L-115.

Boulders, logs and all other objectionable material encountered in excavation shall be removed. All rock and other hard foundation material shall be cleaned of all loose material and cut to a firm surface either level, stepped or serrated, as directed by the RPR. All seams, crevices, disintegrated rock and thin strata

shall be removed. When concrete is to rest on a surface other than rock, special care shall be taken not to disturb the bottom of the excavation. Excavation to final grade shall not be made until just before the concrete or reinforcing is to be placed.

The Contractor shall provide all bracing, sheeting and shoring necessary to implement and protect the excavation and the structure as required for safety or conformance to governing laws. The cost of bracing, sheeting and shoring shall be included in the unit price bid for the structure.

Unless otherwise provided, bracing, sheeting and shoring involved in the construction of this item shall be removed by the Contractor after the completion of the structure. Removal shall be effected in a manner that will not disturb or mar finished masonry. The cost of removal shall be included in the unit price bid for the structure.

After each excavation is completed, the Contractor shall notify the RPR. Structures shall be placed after the RPR has approved the depth of the excavation and the suitability of the foundation material.

Prior to installation the Contractor shall provide a minimum of 6 inches of sand or a material approved by the RPR as a suitable base to receive the structure. The base material shall be compacted and graded level and at proper elevation to receive the structure in proper relation to the conduit grade or ground cover requirements, as indicated on the plans.

115-3.2 Concrete structures. Concrete structures shall be built on prepared foundations conforming to the dimensions and form indicated on the plans. The concrete and construction methods shall conform to the requirements specified in MDOT 1004. Any reinforcement required shall be placed as indicated on the plans and shall be approved by the RPR before the concrete is placed.

115-3.3 Precast unit installations. Precast units shall be installed plumb and true. Joints shall be made watertight by use of sealant at each tongue-and-groove joint and at roof of manhole. Excess sealant shall be removed and severe surface projections on exterior of neck shall be removed.

115-3.4 Placement and treatment of castings, frames and fittings. All castings, frames and fittings shall be placed in the positions indicated on the Plans or as directed by the RPR and shall be set true to line and to correct elevation. If frames or fittings are to be set in concrete or cement mortar, all anchors or bolts shall be in place and position before the concrete or mortar is placed. The unit shall not be disturbed until the mortar or concrete has set.

Field connections shall be made with bolts, unless indicated otherwise. Welding will not be permitted unless shown otherwise on the approved shop drawings and written approval is granted by the casting manufacturer. Erection equipment shall be suitable and safe for the workman. Errors in shop fabrication or deformation resulting from handling and transportation that prevent the proper assembly and fitting of parts shall be reported immediately to the RPR and approval of the method of correction shall be obtained. Approved corrections shall be made at Contractor’s expense.

Anchor bolts and anchors shall be properly located and built into connection work. Bolts and anchors shall be preset by the use of templates or such other methods as may be required to locate the anchors and anchor bolts accurately.

Pulling-in irons shall be located opposite all conduit entrances into structures to provide a strong, convenient attachment for pulling-in blocks when installing cables. Pulling-in irons shall be set directly into the concrete walls of the structure.

115-3.5 Installation of ladders. Ladders shall be installed such that they may be removed if necessary. Mounting brackets shall be supplied top and bottom and shall be cast in place during fabrication of the structure or drilled and grouted in place after erection of the structure.

115-3.6 Removal of sheeting and bracing. In general, all sheeting and bracing used to support the sides of trenches or other open excavations shall be withdrawn as the trenches or other open excavations are being refilled. That portion of the sheeting extending below the top of a structure shall be withdrawn, unless otherwise directed, before more than 6 inches of material is placed above the top of the structure and before any bracing is removed. Voids left by the sheeting shall be carefully refilled with selected material and rammed tight with tools especially adapted for the purpose or otherwise as may be approved.

The RPR may direct the Contractor to delay the removal of sheeting and bracing if, in his judgment, the installed work has not attained the necessary strength to permit placing of backfill.

115-3.7 Backfilling. After a structure has been completed, the area around it shall be backfilled in horizontal layers not to exceed 6 inches in thickness measured after compaction to the density requirements in Item P-152. Each layer shall be deposited all around the structure to approximately the same elevation. The top of the fill shall meet the elevation shown on the plans or as directed by the RPR.

Backfill shall not be placed against any structure until approval is given by the RPR. In the case of concrete, such approval shall not be given until tests made by the laboratory under supervision of the RPR establish that the concrete has attained sufficient strength to provide a factor of safety against damage or strain in withstanding any pressure created by the backfill or the methods used in placing it.

Where required, the RPR may direct the Contractor to add, at his own expense, sufficient water during compaction to assure a complete consolidation of the backfill. The Contractor shall be responsible for all damage or injury done to conduits, duct banks, structures, property or persons due to improper placing or compacting of backfill.

115-3.8 Connection of duct banks. To relieve stress of joint between concrete-encased duct banks and structure walls, reinforcement rods shall be placed in the structure wall and shall be formed and tied into duct bank reinforcement at the time the duct bank is installed.

115-3.9 Grounding. A ground rod shall be installed in the floor of all concrete structures so that the top of rod extends 6 inches above the floor. The ground rod shall be installed within one foot of a corner of the concrete structure. Ground rods shall be installed prior to casting the bottom slab. Where the soil condition does not permit driving the ground rod into the earth without damage to the ground rod, the Contractor shall drill a 4-inch diameter hole into the earth to receive the ground rod. The hole around the ground rod shall be filled throughout its length, below slab, with Portland cement grout. Ground rods shall be installed in precast bottom slab of structures by drilling a hole through bottom slab and installing the ground rod. Bottom slab penetration shall be sealed watertight with Portland cement grout around the ground rod.

A grounding bus of 4/0 bare stranded copper shall be exothermically bonded to the ground rod and loop the concrete structure walls. The ground bus shall be a minimum of one foot above the floor of the structure and separate from other cables. No. 2 American wire gauge (AWG) bare copper pigtails shall bond the grounding bus to all cable trays and other metal hardware within the concrete structure. Connections to the grounding bus shall be exothermic. If an exothermic weld is not possible, connections to the grounding bus shall be made by using connectors approved for direct burial in soil or concrete per UL 467. Hardware connections may be mechanical, using a lug designed for that purpose.

115-3.10 Cleanup and repair. After erection of all galvanized items, damaged areas shall be repaired by applying a liquid cold-galvanizing compound per MIL-P-21035. Surfaces shall be prepared and compound applied per the manufacturer's recommendations.

Prior to acceptance, the entire structure shall be cleaned of all dirt and debris.

115-3.11 Restoration. After the backfill is completed, the Contractor shall dispose of all surplus material, dirt and rubbish from the site. The Contractor shall restore all disturbed areas equivalent to or better than their original condition. All sodding, grading and restoration shall be considered incidental to the respective Item L-115 pay item.

The Contractor shall grade around structures as required to provide positive drainage away from the structure.

Areas with special surface treatment, such as roads, sidewalks, or other paved areas shall have backfill compacted to match surrounding areas, and surfaces shall be repaired using materials comparable to original materials.

Following restoration of all trenching near airport movement surfaces, the Contractor shall thoroughly visually inspect the area for foreign object debris (FOD), and remove any such FOD that is found. This FOD inspection and removal shall be considered incidental to the pay item of which it is a component part.

After all work is completed, the Contractor shall remove all tools and other equipment, leaving the entire site free, clear and in good condition.

115-3.12 Inspection. Prior to final approval, the electrical structures shall be thoroughly inspected for conformance with the plans and this specification. Any indication of defects in materials or workmanship shall be further investigated and corrected. The earth resistance to ground of each ground rod shall not exceed 25 ohms. Each ground rod shall be tested using the fall-of-potential ground impedance test per American National Standards Institute / Institute of Electrical and Electronic Engineers (ANSI/IEEE) Standard 81. This test shall be performed prior to establishing connections to other ground electrodes.

115-3.13 Manhole elevation adjustments. Not Used.

115-3.14 Duct extension to existing ducts. Where existing concrete encased ducts are to be extended, the duct extension shall be concrete encased plastic conduit. The fittings to connect the ducts together shall be standard manufactured connectors designed and approved for the purpose. The duct extensions shall be installed according to the concrete encased duct detail and as shown on the plans.

METHOD OF MEASUREMENT

115-4.1 Electrical handholes shall be measured by each unit completed in place and accepted. The following items shall be included in the price of each unit: All required excavation and dewatering: sheeting and bracing; all required backfilling with on-site materials; restoration of all surfaces and finished grading and turfing; all required connections; temporary cables and connections; and ground rod testing

BASIS OF PAYMENT

115-5.1 The accepted quantity of electrical manholes and junction structures will be paid for at the Contract unit price per each, complete and in place. This price shall be full compensation for furnishing all materials and for all preparation, excavation, backfilling and placing of the materials, furnishing and installation of appurtenances and connections to duct banks and other structures as may be required to complete the item as shown on the plans and for all labor, equipment, tools and incidentals necessary to complete the structure.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
L-115-5.1	FAA Electrical Handhole – Bid Alt 1	Each (EA)

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

American National Standards Institute / Insulated Cable Engineers Association (ANSI/ICEA)

ANSI/IEEE STD 81	IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

Advisory Circular (AC)

AC 150/5345-7	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
AC 150/5345-26	Specification for L-823 Plug and Receptacle, Cable Connectors
AC 150/5345-42	Specification for Airport Light Bases, Transformer Housings, Junction Boxes, and Accessories
AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-53	Airport Lighting Equipment Certification Program

Commercial Item Description (CID)

A-A 59544	Cable and Wire, Electrical (Power, Fixed Installation)

ASTM International (ASTM)

ASTM A27	Standard Specification for Steel Castings, Carbon, for General Application
ASTM A47	Standard Specification for Ferritic Malleable Iron Castings
ASTM A48	Standard Specification for Gray Iron Castings
ASTM A123	Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
ASTM A283	Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A536	Standard Specification for Ductile Iron Castings
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A897	Standard Specification for Austempered Ductile Iron Castings
ASTM C144	Standard Specification for Aggregate for Masonry Mortar
ASTM C150	Standard Specification for Portland Cement
ASTM C206	Standard Specification for Finishing Hydrated Lime

FAA Engineering Brief (EB)

EB #83	In Pavement Light Fixture Bolts

Mil Spec

MIL-P-21035	Paint High Zinc Dust Content, Galvanizing Repair

National Fire Protection Association (NFPA)

NFPA-70	National Electrical Code (NEC)

END OF ITEM L-115

Item L-125 Installation of Airport Lighting Systems

DESCRIPTION

125-1.1 This item shall consist of airport lighting systems furnished and installed in accordance with this specification, the referenced specifications, and the applicable advisory circulars (ACs). The systems shall be installed at the locations and in accordance with the dimensions, design, and details shown in the plans. This item shall include the furnishing of all equipment, materials, services, and incidentals necessary to place the systems in operation as completed units to the satisfaction of the RPR.

EQUIPMENT AND MATERIALS

125-2.1 General.

a. Airport lighting equipment and materials covered by Federal Aviation Administration (FAA) specifications shall be certified under the Airport Lighting Equipment Certification Program in accordance with AC 150/5345-53, current version. FAA certified airfield lighting shall be compatible with each other to perform in compliance with FAA criteria and the intended operation. If the Contractor provides equipment that does not performs as intended because of incompatibility with the system, the Contractor assumes all costs to correct the system for to operate properly.

b. Manufacturer's certifications shall not relieve the Contractor of their responsibility to provide materials in accordance with these specifications and acceptable to the RPR. Materials supplied and/or installed that do not comply with these specifications shall be removed, when directed by the RPR and replaced with materials, which do comply with these specifications, at the sole cost of the Contractor.

c. All materials and equipment used shall be submitted to the RPR for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Clearly mark each copy to identify pertinent products or models applicable to this project. Indicate all optional equipment and delete non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment for which they apply on each submittal sheet. Markings shall be clearly made with arrows or circles (highlighting is not acceptable). The Contractor shall be responsible for delays in the project accruing directly or indirectly from late submissions or resubmissions of submittals.

d. The data submitted shall be sufficient, in the opinion of the RPR, to determine compliance with the plans and specifications. The Contractor's submittals shall be submitted in electronic PDF format, tabbed by specification section. The RPR reserves the right to reject any or all equipment, materials or procedures, which, in the RPR’s opinion, does not meet the system design and the standards and codes, specified herein.

e. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for a period of at least twelve (12) months from final acceptance by the Owner. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner. LED light fixtures must be warranted by the manufacturer for a miln8imum of four (4) years after date of installation, inclusive of all

electronics. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner.

EQUIPMENT AND MATERIALS

125-2.1 Conduit/Duct. Conduit shall conform to Specification Item L-110 Airport Underground Electrical Duct Banks and Conduits.

125-2.2 Cable and Counterpoise. Cable and Counterpoise shall conform to Item L-108 Underground Power Cable for Airports.

125-2.3 Tape. Rubber and plastic electrical tapes shall be Scotch Electrical Tape Numbers 23 and 88 respectively, as manufactured by 3M Company or an approved equal.

125-2.4 Cable Connections. Cable Connections shall conform to Item L-108 Installation of Underground Cable for Airports.

125-2.5 Retroreflective Markers. Retroreflective markers shall be L-853, Type II and shall conform to the requirements of AC 150/5345-39E.

125-2.6 Runway and Taxiway Signs. Runway and Taxiway Guidance Signs should conform to the requirements of AC 150/5345-44.

Signs

Type	Size	Style	Class	Mode	Notes
L-858C	**3**	**4**	**2**	**1**	**Unlighted, 72 Inch Width**

Each sign shall be furnished complete with the specified panels, mounting assemblies, frangible couplings, and mounted on a foundation all as indicated on the plans to provide a complete functional sign.

INSTALLATION

125-3.1 Installation. The Contractor shall furnish, install, connect and test all equipment, support foundations, and support items necessary to ensure a complete and operable airport lighting system as specified here and shown in the plans.

The equipment installation and mounting shall comply with the requirements of the National Electrical Code and state and local code agencies having jurisdiction.

The Contractor shall install the specified equipment in accordance with the applicable advisory circulars and the details shown on the plans.

125-3.2 Testing. Not applicable for unlighted signage.

125-3.3 Shipping and Storage. Equipment shall be shipped in suitable packing material to prevent damage during shipping. Store and maintain equipment and materials in areas protected from weather and physical damage. Any equipment and materials, in the opinion of the RPR, damaged during construction or storage shall be replaced by the Contractor at no additional cost to the owner. Painted or galvanized surfaces that are damaged shall be repaired in accordance with the manufacturer's recommendations.

METHOD OF MEASUREMENT

125-4.1 Method of measurement will be per each complete retroreflective marker installed by the Contractor and accepted by the Engineer.

125-4.2 Method of measurement will be per each complete guidance sign including the in-pavement, frangible supports as a complete unit installed by the Contractor and accepted by the Engineer.

BASIS OF PAYMENT

125-5.1 Payment will be made at the Contract unit price for each complete elevated retroreflective marker installed. This price shall constitute full compensation for furnishing material and equipment, set up, relocation, removal, maintenance thereof, and all other labor, materials, equipment, tools and incidentals necessary to accomplish this item.

125-5.2 Payment will be made at the Contract unit price for each complete guidance sign by the Contractor and accepted by the Engineer. This payment will be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools and incidentals necessary to complete this item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
L-125-5.1	Elevated Retroreflective Marker	Each (EA)
L-125-5.2	L-858C, Unlighted Taxiway Ending Marker, 72 Inch Width, including Frangible In-Pavement Support System	Each (EA)

REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

Advisory Circulars (AC)

AC 150/5340-18	Standards for Airport Sign Systems
AC 150/5340-26	Maintenance of Airport Visual Aid Facilities
AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-39	Specification for L-853, Runway and Taxiway Retroreflective Markers
AC 150/5345-44	Specification for Runway and Taxiway Signs

END OF ITEM L-125

Item MDOT-818 Electrical

818.01 DESCRIPTION

This work consists of providing operating electrical units; removing, salvaging, or disposing of existing electrical components; excavating, backfilling, and restoring the site in accordance with section 816; and disposing of waste excavated materials. Complete this work in accordance with this section, sections 819 and 820, and the contract. For items not specified in section 819 or 820 or the contract, complete the work in accordance with the requirements of the NEC, the NESC, MIOSHA, and the Michigan Department of Licensing and Regulatory Affairs (MDLARA).

Provide personnel who are qualified and experienced in performing the required work. Provide a licensed journeyman electrician supervisor on-site during installation and electrical construction.

818.02. MATERIALS

Provide material in accordance with the following sections:

Granular Material Class II 902

Coarse Aggregate 17A..... 902

Conduit……..... 918

Electrical Grounding System 918

Electrical Wire and Cable..... 918

Direct Burial Cable..... 918

Equipment Grounding Conductor 918

Handholes……..... 918

Wood Poles……..... 918

Concrete, Grade 3500..... 1004

A. Conduit

1. **Direct Burial Application.** Provide a smooth surface conduit of one of the following types for direct burial applications:
   a. Galvanized steel conduit;
   b. Smooth-wall, Schedule 80 rigid (PVC);
   c. Smooth-wall, coilable, Schedule 80 (polyethylene [PE]); or
   d. Rigid fiberglass.
2. Provide Schedule 80 conduit for traffic signal, ITS, and freeway lighting work.
3. **Jacking and Boring Application.** Provide Schedule 80 PVC or Schedule 80 PE conduit for jacking and boring operations.
4. **Directional Boring Application.** Provide Schedule 80 coilable PE conduit for directional boring.

5. **Encased Conduit Application.** Provide Schedule 80 conduit for encased conduit and provide Grade 3500 concrete made with 17A coarse aggregate in accordance with section 1004.

6. **Conduit on Structure Application.** Provide Schedule 80 PVC or rigid fiberglass conduit on structures.

B. **Conductors.** Provide the number of stranded copper conductors for overhead and underground conductors shown on the plans.

C. **Bracket Arm, Clamp On.** This work consists of completing one or more of the following work types at locations shown on the plans:

1. Furnishing and installing a 6-, 9-, 12-, 15-, or 18-foot clamp on bracket arm.

2. Removing and disposing of an existing 6-, 9-, 12-, 15-, or 18-foot clamp on bracket arm.

As applicable, this work includes removal or installation of clamp-on bracket arm of the size specified on the plans and any associated materials required to ensure a complete removal or installation, as specified for a location.

Fabricate the bracket arm truss tubes from 2⅜-inch OD by 0.120-inch-thick steel tubing meeting the requirements of ASTM A500/A500M for Grade B steel and subsection 105.10. Weld to a ⅜-inch-thick steel mounting plate meeting the requirements of ASTM A36/A36M.

Weld ½- by 2-inch flat bar meeting the requirements of ASTM A36/A36M between bracket arm tubes to form the truss. Weld ¼-inch flat bar steel gussets between arm tubes and mounting plate. Complete welding in accordance with AWS D1.1 and the contract.

Hot dip galvanize the bracket arm, all brackets, and hardware after fabrication and welding according to ASTM A123/A123M and ASTM A153/A153M where applicable.

D. **Steel Pole Mount.** Use U-bolts meeting the size requirements below to attach bracket arms to steel poles. Use hex nuts, flat washers, and lock washers to secure U-bolts. U-bolts and hardware must meet the requirements of ASTM A36/A36M steel.

Use ⅝-inch rod U-bolts for pole diameters equal to or greater than 8½ inches but less 9⅛ inches. Use ¾-inch rod U-bolts for pole diameters equal to or greater than 9⅛ inches and equal to or less than 10¼ inches.

E. **Wood Pole Mount**. Fabricate the pole-mounting plate from ⅜-inch-thick steel plate meeting the requirements of ASTM A36/A36M and weld gussets to the arm tubes. There must be one plate per arm tube. Each plate must incorporate two 0.562-inch-diameter holes and one 0.687- by 1.50-inch keyhole for lagging to the wood poles.

818.03. CONSTRUCTION

Contact the MDLARA for electrical service inspection prior to energizing services.

A. **Conduit.** Build straight conduit runs. If the contract requires sweeps, use the largest radius that will fit the work space available for each sweep. Do not install more than 360 degrees of bends per conduit run between junction boxes per NEC.

Provide conduit fittings and use methods of joining conduits, including conduit cement, in accordance with current NEC methods. If the NEC does not clearly describe the method, install the conduits in accordance with the manufacturer's recommendation. Obtain the Engineer's approval of installation methods before beginning work.

Attach end bells on the ends of conduits entering handholes to prevent damage to the cable.

Install continuous coilable conduit between handholes.

For conduit not terminating in structures such as manholes, handholes, or foundations, extend the conduit 2 feet beyond pavement limit unless otherwise required. Plug unoccupied conduit.

Verify that new conduit inserted into existing manholes or handholes does not interfere with racking, training of cables, or both. Do not disturb existing cables.

1. **Bends.** Bend conduit to the radii specified in the current NEC. For conduit entering foundations or cable pole envelopes, provide conduit with factory bends.
2. **Excavation.** Excavate the conduit trench to provide an earth cover of at least 30 inches over the finished conduit.
3. **Drainage.** Grade the trench to provide drainage to handholes.
4. **Grades.** Stake conduit grades at no greater than 50-foot intervals or as directed by the Engineer. Create a grade that slopes at least
   4 inches over 100 feet to the lowest manhole or handhole or from the middle of the conduit run toward both holes.
5. **Backfill.** Tamp the bottom of the trench to produce a smooth, flat, or gently sloping surface before placing the conduit. Backfill trenches outside the roadbed with excavated material, suitable for backfill, as determined by the Engineer. If excavated material is unsuitable, backfill the trenches with Class II granular material in accordance with section 204.

   Backfill trenches within the limits of the roadbed with Class II granular material in accordance with section 204.
6. **Supports.** Provide support for conduit running through holes built over or into existing duct. If ducts are built into an existing handhole, build a 4-inch tapered pocket into the wall. Build new service ducts into existing handholes without interfering with cable racking. Install required inserts.
7. **Clearances.** Do not allow conduit or concrete encasement to contact obstructions. Provide a vertical clearance of 9 inches, except provide at least 12 inches of clearance for conduit running parallel to water lines, gas mains, and other underground structures not part of the electrical system.

The Engineer and the owner of the obstruction will determine the method of protection if the Contractor cannot provide the required 12-inch clearance.

Exposed Conduit. For high voltage lines, minimum clearance must follow MIOSHA, NESC, and utility standards.

8. **Clearing.** After installing conduit runs, pull a mandrel 12 inches long, or shorter for conduit runs with bends, and with a diameter ½ inch smaller than the conduit. Attach a swab or cleaning device designed to clear the conduit to the mandrel. Notify the Engineer before performing clearing work.

9. **Encased Conduit.** Encase conduit runs in Grade 3500 concrete. Space adjacent conduits at least 1 inch apart and fill the space with concrete. Provide a conduit encasement with at least 3 inches of concrete around the conduit. If steel reinforcement is required, separate the reinforcing bars from the conduits with 2 inches of concrete. Provide at least 3 inches of concrete cover between the reinforcing bars and the surface of the encasement. Stagger conduit joints vertically.

   Use concrete, plastic, or bituminized fiber as separators, spacers, blocks, or supports that will remain in the finished concrete encasement. If installing 20-foot lengths of conduit, place spacers no greater than 7 feet apart. If installing 10-foot lengths of conduit, place spacers no greater than 5 feet apart.

   Prevent the conduit bank from floating after concrete placement by anchoring the bank to stakes at intervals no greater than 10 feet apart in firm soil and no greater than 5 feet apart in loose soil.

   Verify that the concrete fully encases the conduit.

   a. **Tier by Tier Method.** Grade the trench and place a foundation of concrete at least 3 inches thick in the bottom of the trench. If steel reinforcement is required, place the concrete at least 5 inches thick with reinforcing bars in place. Lay the bottom tier of conduits, separated by spacers. Fill the space between conduits with concrete and cover the conduits to the height of the next conduit tier. Construct succeeding tiers as specified for the first tier. Provide continuous placement of successive tiers of conduit with interruptions no greater than 45 minutes.

   b. **Build-Up or Monolithic Methods**. Grade the trench and place masonry supports at intervals of 3 to 5 feet or a foundation of concrete at least 3 inches thick in the bottom of the trench. If steel reinforcement is required, place the concrete at least 5 inches thick with the reinforcing bars in place. Place the conduit using plastic or concrete separators to erect a rigid, self-supporting structure of conduit. Place the concrete to fill the spaces between the conduits completely, without damaging or displacing them.

      Notify the Engineer prior to encasing the conduit in concrete.

      Place a coupling on the ends of conduit and install a removable plug. Sheet and brace the trenches as required. Support pipes or other structures exposed in the trenches as required to prevent damage.

10. **Directional Bore.** Bore by augering or jacking a steerable rod and pulling back a cone reamer that expands the soil that cuts a hole to the required diameter. Use a reamer with a diameter no greater than 2 inches larger than the conduit, as shown on the plans.

    The Contractor may use a drilling fluid of water and bentonite in directional drilling. The Contractor may use a polymer for lubrication in the drilling fluid.

    Place directional bore or drill equipment and supplies so they do not interfere with traffic or with the use of adjacent property. Locate equipment and supplies a minimum distance from the edge of pavement as directed by the Engineer. Place access pits in the location of handholes at the boring termination points, as shown on the plans or directed by the Engineer.

11. **Jacking and Boring**

    a. **Compaction Auger (packer, expander).** Auger a rotating stem under the roadway and then pull back a series of graduated cones that displace the soil to obtain the required diameter.

    b. **Hydraulic Push Rods or Stem (pipe puller, packer).** Push rods or stems under the roadway with a hydraulic ram and pull a series of graduated cones that displace the soil to obtain the required diameter.

    c. **Other Methods.** The Engineer may approve other jacking and boring methods before construction. Do not jet or use water or air ahead of the casing.

       The Contractor may use air rams longitudinally in the right-of-way but under roadways only if approved by the Engineer.

       Before jacking and boring, excavate a starter alignment trench to the elevation of the proposed conduit. Excavate a length of level trench at least 15 feet long for trenches up to 4 feet deep, and increase the trench length 5 feet for each additional 1 foot of depth.

       Use guide rails, sills, or other positive alignment devices to start the crossing. Restrain drive rods against horizontal and vertical movement.

       If using heads to develop an opening with a diameter greater than 2 inches, develop openings by increasing the head size in 1 inch increments.

       If the highway is super-elevated, start the bore from the lower side of the pavement.

       The Engineer will determine whether conditions warrant the use of sheeting and bracing. Use sheeting and bracing for boring as directed by the Engineer if access pits are located within the 1:1 slope from the edge of paved surfaces or back of curbs.

       Place access pits in the location of handholes at the boring termination points, as shown on the plans or directed by the Engineer.

       Provide the bore and jack record sheet or log if requested by the Engineer.

Control groundwater entering the excavation from seepage layers and lenses or pockets of saturated material from inside the excavation using drainage, bailing, pumping, or other methods. Do not remove or disturb adjacent soil while draining the groundwater.

If ordinary methods of drainage prove unsatisfactory, as determined by the Engineer, drain excavations as required.

12. **Record Drawings.** Within 5 days after completing conduit work or installing working cables, provide a record drawing to the Engineer. Show deviations from the original plans. Measure the lengths from the inside walls of the handholes and the center of post foundations and cable poles.

B. Electrical Wire and Cable

Permanently tag wires and cables in manholes, handholes, and cabinets at the points of entrance, exit, splicing, and termination. Label new and affected wires and cables to indicate the source and use of each where above grade. Tag wires and cables in manholes and handholes with a stamped brass tag.

Provide wires and cables with an additional length of at least 10 feet in each manhole and handhole.

Seal cable ends where the plans show coiling of cable.

Cut and remove cables within handholes and manholes for abandoned underground cables as shown on the plans.

Permanently label detector wiring harnesses at the cabinet terminal strip with the source and use.

Do not install service entrance conductors in handholes or vaults containing other wires or cables.

Do not splice signal cables or interconnect cables for traffic signals unless indicated in the plans.

C. **Direct Burial Conductors.** Provide and install direct burial single conductors.

1. **Approval.** Unless otherwise specified in the contract, the Department is the agency responsible for maintaining direct burial conductor facilities. Provide certified test reports to the maintaining agency upon request.
2. **Installation.** Install direct burial conductors as shown on the plans and in accordance with the manufacturer's recommendations. Do not drag conductors on the ground. Do not splice conductors underground. Install conductors in continuous runs between manholes, handholes, or foundations.
3. **Location.** Install direct burial conductors parallel to the edge of pavement, along the shoulder edge, clear of guardrail locations. Place conductors in a straight line between visible reference points such as handholes or light standards.
4. **Excavation.** After compacting the subbase in the shoulder area to at least the elevation of the top of the base course, cut a trench along the shoulder edge for placement of the conductors.

Remove rocks or other sharp objects from the trench. Lay the conductors in the trench.

Install marking tape from 6 to 18 inches above underground conduit or cable. Do not install marking tape above jacked and bored conduit.

The Department will provide the marking tape.

Provide 3 feet of cover over direct burial cable installed outside the shoulder.

5. **Conductors Installed In Conduit.** If installing direct burial conductors in conduit, use clean conduit, free of rough spots.

   Avoid damage to insulation and conductor jackets during installation.

   When required, use lubricating compounds approved by the conductor manufacturer. Use non-injurious lubricants listed by nationally recognized testing laboratories on conduits, conductors, insulations, or jackets.

   Provide slack in each run of cable.

   Group multiple conductors trained through a box, manhole, or handhole, by circuit. Bundle them using cable ties, and support them to reduce pressure or strain on conductor insulation. Bend wire and cable in accordance with the manufacturer's recommended bending radius during installation and in permanent placement.

   Use a cable-pulling apparatus with no sharp edges or protrusions.

6. **Testing.** Test direct burial conductors for continuity, shorts, and grounds after installation and backfill. Replace conductors that fail field tests with new conductors at no additional cost to the Department.

D. **Equipment Grounding and Bonding.** Provide and install grounding electrode conductors to provide a continuous grounding electrode system. Install grounding electrode conductors and connect to light standard bases, strain poles, pedestal bases, span wires, concrete-encased electrodes, ground rods, and service disconnects. For traffic signals, all equipment listed above that is associated with a single cabinet must be bonded to a continuous connection from grounding electrode system. Do not use equipment grounding conductors to provide continuity of the grounding electrode system. Install equipment grounding conductors in the same raceway or trench as the current-carrying conductors and connect to the ground bus at the electrical source and to the grounding termination at the utilization equipment.

   If installing conductors directly in earth with no conduit protection, the Contractor may use a bare conductor. Install the conductor at the same depth as a conductor installed in conduit.

   If installing the conductors in conduit, use an insulated conductor, color-coded green in accordance with subsection 918.04.A. Do not damage the conductor during installation.

E. **Handholes**. Provide and install, remove, salvage, reconstruct, abandon, or adjust handholes, including covers and fittings as shown on the plans.

If the plans show existing cables maintained in new handholes, break and remove conduit and concrete encasements to the walls of the new handhole. Extend existing cables, train, rack, and support on the walls of the handhole.

1. **Remove or Abandon.** Remove handholes completely or abandon in accordance with section 204.
2. **Adjust.** Adjust handholes in accordance with section 403.
3. **Reconstruct.** Reconstruct handholes in accordance with section 403. Use existing frames and covers unless otherwise directed by the Engineer.
4. **Installation**. Ensure that handholes are flush with the pavement surface and 1 inch above grade outside paved areas. Install the frame and cover flush with the top of the handhole.

   Use CIP or precast reinforced concrete handholes.

   Make the inner surface of reinforced handholes smooth. Sandblast castings. Cast handholes free of pouring faults, blow holes, cracks, and other imperfections. Cast handholes that are sound, true to form and thickness, clean, and finished.

   Provide and install cable racks and hooks.

   Plug unused conduit entrances and conduit openings for future use by others with removable plastic plugs or other plugs approved by the Engineer.

   Remove rubbish, construction debris, and water from handholes. Grout conduits from outside the handholes to inside the handholes.
5. **Excavation.** Excavate to the diameter and depth for installing handholes at locations shown on the plans.
6. **Drainage.** Cast drain holes at the bottom of the handhole. Provide drainage of handholes installed over underground conduits and on bridge decks.
7. **Backfill.** Install the handhole on Class II granular material. The Engineer will determine whether excavated material meets the backfill requirement. Use Class II granular material if the Engineer determines that excavated material does not meet the backfill requirement.

F. Electrical Service Requirements

1. **Unmetered Service.** Provide NEMA type 4X service disconnecting means with stainless steel enclosures, unless otherwise required. The Department will provide means for padlocking the operating handles in the open or closed position. If directed by the Engineer, run conduit on the outside of the pole. Support the conduit using two-hole galvanized support brackets, spaced no greater than 3 feet apart. Bond the conduits and equipment as required by the NEC, utility company, and the contract. Use waterproof metal elbows with removable covers to enter and exit service disconnects and controllers.
2. **Metered Service**. Provide NEMA type 4X service disconnecting means with stainless steel enclosures, unless otherwise required. The Department will provide means for padlocking the operating handles in the open or closed position. On wood poles, connect the meter socket to

the service disconnect using at least 1½-inch-diameter Schedule 80 PVC or galvanized metal conduit. On steel poles, connect the wiring between the meter socket and the service disconnect on the inside of the pole. If directed by the Engineer, run conduit on the outside of the pole. Support the conduit using two-hole galvanized support brackets, spaced no greater than 3 feet apart. Bond the conduits and equipment as required by the NEC, utility company, and the contract. Use waterproof metal elbows with removable covers to enter and exit meters, service disconnects, and controllers.

3. **Electrical Service Removals**. Contact the local power company shown on the plans to coordinate removal of metered service and power feed. Perform removal work in accordance with the NEC, the contract, and the local power company standards.

G. **Wood Pole.** Provide and install, relocate, or remove wood poles and associated hardware for supporting span wire and bracket-arm-mounted traffic signals, and guying the pole per span.

Tamp the earth replaced around new or relocated poles. Fill, tamp, and level holes after removing poles. Use hot dip galvanized turnbuckles, tension tie bars, and associated steel hardware in accordance with ASTM A153/A153M.

Set wood poles to the minimum depths specified in Table 818-1:

Table 818-1:
Wood Pole Lengths and Depths

Pole Length	Depth
35-foot Class 4 pole	6 feet
40-foot Class 4 pole	6 feet
45-foot Class 4 pole	6½ feet
50-foot Class 4 pole	7 feet
55-foot Class 4 pole	7½ feet
60-foot Class 4 pole	8 feet

818.04. MEASUREMENT AND PAYMENT

Unless otherwise required, the unit prices for the pay items listed in this subsection include the cost of excavation, granular material, backfill, and disposal of waste excavated material. Restoring the site in kind in accordance with section 816 will be paid for separately.

A. **Conduit.** The Engineer will measure conduit in place, from the inside walls of manholes, and the centers of handholes, post foundations, and cable poles.

The unit prices for **Conduit, Rem** include the cost of removing the type, number, and size of conduit shown on the plans.

The unit prices for **Conduit, (type), inch** and **Conduit, DB, (number), __ inch** include the cost of installing the type, number, and size of conduit shown on the plans, and installing marking tape.

The unit price for **Conduit, (type), inch, Structure** includes the cost of providing and installing the conduit components, hardware, and other appurtenances required.

The unit price for **Conduit, Jacked Bored, (number), inch** includes the cost of installing rigid metal, or Schedule 80 PVC conduit.

The unit price for **Conduit, Directional Bore, (number), inch** includes the cost of installing Schedule 80 PE conduit.

The unit price for **Conduit, Encased, (number), inch** includes the cost of the following:

1. Installing conduits;
2. Installing sheeting and bracing;
3. Removing boring pits; and
4. Filling voids.

The unit price for **Conduit, Schedule (number), inch** includes the cost of installing conduit approved for direct burial applications, as specified in subsection 818.02.A.1, and installing marking tape.

B. **Direct Burial Cable.** Not Used.

C. **Cable, Removal.** The unit prices for **Cable, Rem** and **Cable, (type), Rem** include the cost of dead ending, circuit cutting, work required to leave circuits operable, and disposing of the removed cables, wire, hardware, and other appurtenances.

The unit prices for other items of work include the cost of abandoning cables and conduit.

D. **Cable, Pole Dismantle.** Not Used.

E. **Cable, P.J.; Cable, Section; Cable, Shielded, and Cable, Street Lighting.** Not Used.

F. **Cable, Equipment Grounding Wire.** Not Used.

G. **Electrical Service, Removal.** Not Used.

H. **Handholes (Hh).** Not Used.

I. **Service Disconnect.** Not Used.

J. **Metered Service.** Not Used.

K. **Unmetered Service.** Not Used.

L. **Wood Pole.** Not Used.

M. **Concrete Pole, Fit Up.** Not Used.

N. **Steel Pole, Fit Up.** Not Used.

O. Bracket Arm. Not Used.

818.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-818.05.01	Airfield Light Can Bases, Rem	Each (EA)
MDOT-818.05.02	Cable/Conduit, Rem	Linear Foot (LF)
MDOT-818.05.03	Place Salvaged Security Camera and Pole (Including New Foundation)	Each (EA)
MDOT-818.05.04	THWN Cables	Linear Foot (LF)
MDOT-818.05.05	COMM Cables	Linear Foot (LF)
MDOT-818.05.06	Remove, Salvage, & Install Security Camera on Hangar	Each (EA)
MDOT-818.05.07	Airfield Light Can Bases, Rem	Each (EA)
MDOT-818.05.08	Cable/Conduit, Rem	Linear Foot (LF)
MDOT-818.05.09	Place Salvaged Security Camera and Pole (Including New Foundation)	Each (EA)
MDOT-818.05.10	THWN Cables	Linear Foot (LF)
MDOT-818.05.11	COMM Cables	Linear Foot (LF)

END OF ITEM MDOT-818

FAA-C-1391d
September 2014
SUPERSEDING
FAA-C-1391c
May 2012

DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION
SPECIFICATION

INSTALLATION, TERMINATION, SPLICING, AND TRANSIENT/SURGE PROTECTION OF UNDERGROUND ELECTRICAL DISTRIBUTION SYSTEM POWER CABLES

This specification is approved for use by all Departments of the Federal Aviation Administration (FAA)

FOREWORD

1. This specification provides requirements for the installation of FAA-owned and maintained underground electrical line distribution (ELD) systems in support of FAA facilities. The ELD systems include power cable and associated components on the exterior, commercial power supply side of the circuit at the airfield or remote site through to the service entrance power panels of FAA facilities.

2. This specification applies only to FAA medium-voltage (MV) and low-voltage (LV) underground power cables, and to a limited extent to overhead lines that may form a part of an FAA-owned circuit. It does not apply to control, telecommunication, or facility service entrance (load side) wiring. For standards pertaining to these non-power cable and electrical systems, consult the appropriate office of primary responsibility for applicable standards.

3. Power for airfield lighting cables has a separate set of standards and procedures. Refer to the appropriate FAA Advisory Circular (AC) 150/5340 and associated governing standards.

4. This is an update to an existing specification. It assimilates recent utility industry knowledge concerning ELD systems, with the aim of providing safer, more reliable FAA underground MV and LV ELD systems.

5. Changes in this version of the document include (see change history, page iv):

   a. Revised from “c” version to “d” version.
   b. Miscellaneous updates collected from field comments.
   c. Submittals section updated; submittals matrix added as an appendix.
   d. Duct joining processes added, with special consideration of joining HDPE sections (see also appendix for sample bonding adhesives data sheet).
   e. Product section updated (added power cable, transformers, switchgear/sectionalizers, service disconnects, terminations/splices, overcurrent devices, underground duct systems, and ducts and fittings, etc).

6. This specification is intended to ensure that minimum FAA requirements are met based on current commercial practices relating to safety, reliability, and restorability of FAA electrical line distribution systems. Contractors are encouraged to provide innovative, best-value solutions wherever possible within the bounds of these requirements.

Comments, suggestions, or questions on this document should be addressed to: Federal Aviation Administration, AJW-22, Power Services Group, Power Cable Program, 800 Independence Ave., S.W., Washington, DC 20591, https://employees.faa.gov/org/linebusiness/ato/operations/technical_operations/atc_facilities/power_services/power_cable/

Approved by:

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11/5/14
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10/30/14
Date

Change History

1. Originator Name and Address AJW-22, Power Services Group	2. [] Proposed	3. Code Identification	4. Document No. FAA-C-1391c
Washington, DC	[X] Approved	5. Code Identification	6. DCN No.
7. System Designation	8. Related ECR/NCP No. ATO0W-CABLE-1023	9. Contract No.	10. Contractual Activity N/A
11. Product Integration Plan		12. Effectivity	

This notice informs recipients that the standard identified by the number (and revision letter) shown in block 4 has been changed. The pages changed by this DCN (being those furnished herewith) carry the same date as the DCN. The page numbers and dates listed below in the summary of changed pages, combined with non-listed pages of the original issue of the revision shown in block 4, constitute the current version of this specification.

13. DCN No.	14. Pages changed	S*	A/D*	15. Date
	Summary - general: a. Deletion of requirements for non-electrical-line-distribution (non-ELD) systems, including communications and telecommunications cables (both copper and FOTS), control cables, and constant-current-regulated runway approach and edge lighting power cables. Basic separation requirements between ELD and non-ELD cables have been retained. Installation standards and specifications for the non ELD systems may be found by consulting the appropriate office of primary responsibility. b. Emphasis on product changes in FAA ELD systems from the older 2.4 kV to 4.16 kV distribution circuits to the newer industry standard medium voltage systems, e.g., 3-phase/7200 V (phase to neutral). The Power Cable Program favors 15 kV rated cables and equipment to bring FAA ELD systems up to compatibility with the utility industry and to meet future FAA needs. c. Increased attention to the protection of sensitive internal constituent parts of MV cable systems during installation, by (1) the imposition of stringent tests meeting IEEE criteria, and (2) using proper cable pulling, splicing, and terminating techniques. d. Addition of power cable acceptance testing process for newly installed cables (text main body and Appendix C). Acceptance tests classified as destructive by the IEEE, such as the DC high potential (HIPOT) test, shall no longer be performed on in-service power cables. e. Treatment of the qualifications of MV “qualified persons” during installations.			1/24/2012
	Details – changes: a. Non ELD systems, deletions from FAA-C-1391b version: pp. 1-4, 7-15, 17-19. Sections/paragraphs affected: 2.1.2, 2.1.3, 3.1.2, 3.2.1, 3.2.2, 3.4, 3.4.1.1, 3.4.1.2, 3.4.2.2, Table I, 3.4.3, 3.4.3.1, 3.4.4, 3.4.5, 3.5.1, 3.5.2, 3.6, 4.2, 4.3, 4.5, 4.5.1, 4.5.2, 4.6, 4.6.1, 4.6.2, 4.6.3, App A.			1/24/2012
	Details – changes: b. Product changes, additions in FAA-C-1391c: cable 3.3.6.2; 15 kV surge protection 5.8.2; 15 kV splice kits 5.9.			1/24/2012
	Details – changes: c. Installation of cables, additions in FAA-C-1391c: splice procedures 5.9; cable pulling 5.5.12 and App B; cable end sealing 5.5.11; installer qualifications 3.3.3.2; 50/60 Hz offline partial discharge test 3.3.6.3, 3.3.6.4.			1/24/2012
	Details – changes: d. Acceptance testing procedures, additions in FAA-C-1391c: 3.3.6; Appendix C.			1/24/2012
	Details – changes: e. Qualified persons and contractors, change in FAA-C-1391c: 3.3.3 (all), 3.3.6.4, 5.9.			1/24/2012
	Updated document from “c” version to “d” version.			4/4/2014
	Miscellaneous updates collected from field comments.			4/4/2014
	Submittals updated, products updated (added power cable, transformers, switchgear/sectionalizers, service disconnects, terminations/splices, overcurrent devices, underground duct systems, and ducts and fittings).			4/4/2014
	Manhole cover wheel loading and guard wire grounding upgraded.			8/15/14

CONTENTS

1. SCOPE 1
2. APPLICABLE DOCUMENTS 2
2.1 General 2
2.2 Order of precedence 2
2.3 Government documents 2
2.3.1 FAA orders, standards, specifications, and handbooks 2
2.3.2 Other Government documents, drawings, and publications 3
2.4 Non-Government publications 5
3. GENERAL 10
3.1 Definitions 10
3.2 Submittals 10
3.3 Quality assurance 12
3.3.1 Quality plan 12
3.3.2 Quality control 12
3.3.3 Qualifications of personnel 13
3.3.4 Receiving, storing, and protecting 14
3.3.5 Sequencing and scheduling 15
3.3.6 Cable testing 15
4. PRODUCTS 18
4.1 Product options and substitutions 18
4.2 Power cable 18
4.3 Transformers 18
4.3.1 High voltage transformers (>600 volts) 18
4.3.2 Low-voltage transformers (<600 volts) 19
4.4 Switchgear and sectionalizers 19
4.5 Service disconnecting means 20
4.6 Terminations and splices 20
4.6.1 Terminations 20
4.6.2 Splices 20
4.7 Overcurrent protective devices 21
4.8 Underground duct systems 21
4.8.1 Concrete-encased rigid nonmetallic conduit 21
4.8.2 Plastic-coated steel conduit 21
4.8.3 Direct buried rigid nonmetallic conduit 22
4.8.4 Rigid metal conduit (RMC) 22
4.9 Corrosion protection tape 22
4.10 Insulating bushings 22
4.11 Grounding bushings 22
4.12 Sweeps 23
4.13 Duct spacers 23
4.14 Duct plugs 23
4.15 Duct sealant and joint filler 23
4.16 Underground duct and cable warning tape 23
4.17 Pull wires and tape 24

4.18 Precast electrical manholes and hand holes, accessories 24
4.18.1 Manholes and hand holes 24
4.18.2 Manholes accessories 26
4.19 Grounding cables 26
4.20 Ground rods 26
4.21 Weather heads on risers, drip loops 26
4.22 Electrical equipment enclosures 26
4.23 Equipment vaults and pads 27
4.24 Bollards 28
5. EXECUTION 29
5.1 Scheduling of work 29
5.2 Existing FAA buried cable and ducts 29
5.2.1 FAA documentation 29
5.2.2 FAA marking of known buried cables and ducts 29
5.2.3 Other buried cables, ducts, piping and items 29
5.3 Safety during construction and testing 30
5.4 Excavation and trenching 30
5.4.1 Depth requirements 31
5.4.2 Survey requirements 32
5.5 Underground duct systems 34
5.5.1 Preparation and excavation for underground ducts 34
5.5.2 Backfilling 36
5.5.3 Restoration 36
5.5.4 Duct installation 37
5.5.5 Manhole and hand hole installation 37
5.5.6 Mandrel requirements 39
5.5.7 Spare ducts, preparation 40
5.5.8 Duct protection 40
5.5.9 Ducts without concrete encasement 40
5.5.10 Separation of cables 41
5.5.11 Installation of cables 41
5.5.12 Cable pulling 42
5.6 Medium-voltage direct earth buried cables 45
5.7 Cable installation in manholes 48
5.8 Cable terminations, connections, surge protection, and fault protection 48
5.8.1 Cable terminations and connections 48
5.8.2 Connections to a three-phase engine generator 48
5.8.3 Surge protection 49
5.8.4 Fault isolation 50
5.9 Splices 50
5.10 Equipment racks and disconnect switches 52
5.11 Grounding of ELD systems 52
5.11.1 Power cables, multigrounded neutral wires and shields 52
5.11.2 Cable guard wires 53
5.11.3 Manholes and hand holes 54
5.11.4 Equipment and equipment enclosures 56

5.11.5 Surge arresters 57
5.11.6 Conduit and fittings 57
5.11.7 Low-voltage cable runs to facility service entrances 57
5.11.8 Installation details 58
5.12 Cable tagging, equipment markers and labels, and safety signs 59
5.12.1 Cable tags 59
5.12.2 Equipment markers and labels 60
5.13 Cable markers 60
5.13.1 Concrete markers for DEB cable 60
5.13.2 Special-purpose and near-surface markers 62
5.14 Acceptance and inspection procedures 62
APPENDIX A—Surge Arrester Performance Data 63
1. SCOPE 63
2. APPLICABLE DOCUMENTS 63
2.1 Non-government publications 63
3. REQUIREMENTS 64
3.1 Performance Requirements 64
3.1.1 General 64
3.1.2 Placement 64
3.1.3 IEEE Standard C62.11 65
3.1.4 Service conditions 65
APPENDIX B—Cable Pulling Calculations 67
APPENDIX C—Acceptance testing of newly installed FAA power cables 71
SAFETY REQUIREMENTS, GENERAL 71
1. INSULATION RESISTANCE TEST 72
1.1 Theory of Operation 72
1.2 Parameters and Tolerance limits 72
1.3 Test Schedules 72
1.4 Safety and Test Procedure 73
1.4.1 Safety 73
1.4.2 Test Procedure 73
2. AC VLF FIELD TEST 74
2.1 Theory of Operation 74
2.2 Parameters and Tolerance Limits 75
2.3 Test Schedules 75
2.4 Safety and Test Procedure 75
2.4.1 Safety 75
2.4.2 Test Procedure 76
3. OFFLINE 50/60 Hz PARTIAL DISCHARGE TEST 77
3.1 Theory of Operation 77
3.2 Parameters and Tolerance Limits 77
3.3 Test Schedules 78
3.4 Safety and Test Procedure 78
3.4.1 Safety 78
3.4.2 Test Procedure 78
APPENDIX D—Acronyms/glossary 79

APPENDIX E--Submittals Matrix..... 82
APPENDIX F—HDPE-to-HDPE and HDPE-to-PVC Conduit Adhesive - Sample Product 84

1. SCOPE

This specification defines the minimum requirements for the installation of medium voltage and low voltage (600 V) electrical line distribution (ELD) power cables buried directly in the earth or installed in underground duct or conduit. The industry definition of medium voltage is between 600 V and 34,500 V nominal voltage line to ground. The work includes surveying, trenching, and backfilling, installation of cables, conduits, concrete-encased ducts, hand holes, manholes, duct markers, joints and splicing, terminating, providing surge protection, and testing of cables for acceptability of the finished ELD. In addition, this specification defines the responsibilities of the contractor with respect to safety, quality assurance, and quality control during the installation and testing of ELD systems.

This specification covers installation and acceptance testing of FAA ELD systems only. For FAA power cable maintenance directives, refer to FAA Order 6950.22.

This specification applies to installation of medium and low voltage facility electrical supply power cables and associated equipment only. These systems provide facility power from the power supplier's primary service to the service entrance power panels of FAA facilities. For detailed information on the installation of non-ELD cable systems such as control cables, fiber optics telecommunication (FOTS) cables, communication cables, etc., consult with the office of primary responsibility (OPR) for guidance. The 2400-V shielded constant current power cables serving runway edge lighting fixtures have their own standards and are not the subject of this specification. Consult the appropriate office of primary responsibility and the airport circulars for guidance. For basic separation requirements of FAA utility power cable systems from non-electrical-power cable systems, consult the section of this specification entitled, "Separation of Cables" (5.5.10). When physically integrating non-ELD cables with power cables, do not assume all of the provisions of FAA-C-1391 apply without first coordinating with the appropriate OPR and the FAA onsite project engineer responsible for integration of multiple cable assets.

Non-ELD OPRs consist of:

a. **AJW-45 Ground-Based Navaids Group,**
b. **AJW-46 Lighting Systems Group,**
c. **AJW-52 Communications Systems Engineering Group,**
d. **AJW-53 Telecommunication Services Group,**
e. **AJW-55 Air-Ground Data Communications Group,**
f. **AJW-56 Air-Ground Voice Communications Group,**
g. **Others (as applicable).**

2. APPLICABLE DOCUMENTS

2.1 General

Due to the continuous updating of Government documents, the FAA Contracting Officer and/or the FAA Project Engineer must specify the document version and publication date current at the time of contract award or project design. The documents below form a part of this specification. Some of the FAA documents listed are out of date but are still applicable; reference the notations next to each reference provided. FAA tailoring organizations should consult with the offices of primary responsibility to obtain the most recent applicable documentation.

2.2 Order of precedence

In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.3 Government documents

The following citations are government documents that are used as references in this specification.

2.3.1 FAA orders, standards, specifications, and handbooks

The following FAA orders, standards, specifications, and handbooks form a part of this document to the extent specified herein. Unless otherwise stated, requirements contained in these documents are as cited in the project solicitation or contract. (Copies of FAA orders, standards, specifications, handbooks, drawings, and other applicable FAA documents may be obtained from the Contracting Officer issuing the invitation-for-bids or request-for-proposals. Requests should fully identify the material desired; for example: specification, standard, amendment, drawing numbers [drawings possessing standard FAA signature block], and dates. Requests should cite the invitation for bids, request for proposals, the contract involved, or other source of the requested material.)

2.3.1.1. ORDERS

JO 3900.XX	Air Traffic Organization Electrical Safety Program [Future]
JO 6750.16	Siting Criteria for Instrument Landing Systems
JO 6950.27	Short Circuit Analysis and Protective Device Coordination Study [contact PSG Systems Engineering for arc flash calculations]

2.3.1.2 STANDARDS

FAA-STD-XXX	Underground Electric Line Distribution (ELD) Systems [Future]
FAA-STD-019	Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities

2.3.1.3 ADVISORY CIRCULARS AND SPECIFICATIONS

150/5300-13	Airport Design
150/5320	Surface Drainage Design
150/5370	FAA Standards for Specifying Construction of Airports
FAA-E-113	Poles, Wood, Treated
FAA-E-2793	Cable, Electrical Power, 2,000 to 35,000 Volts
FAA-E-2013	Cable, Electrical Power, Exterior 600 Volts

2.3.1.4 HANDBOOKS

FAA-HDBK-XXX	Underground Electric Line Distribution (ELD) Systems [Future]

2.3.2 Other Government documents, drawings, and publications

The following Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

American Association of State Highway & Transportation Officials Specifications

AASHTO HB-17	Standard Specifications for Highway Bridges.
AASHTO HS-20	Standard Specifications for Highway Bridges

Occupational Safety and Health Administration Codes

Part 1926	Safety and Health Regulations for Construction.

Military Specifications

MIL-I-3825	Insulating Tape, Self-Fusing
DLA A-A-50563	Conduit Outlet Boxes, Bodies, and Entrance Caps, Electrical: Cast Metal
DLA A-A-59213	Splice Connectors
DLA A-A-59214	Junction Box: Extension, Junction Box; Cover, Junction Box (Steel, Coated with Corrosion-Resistant Finish)
DLA A-A-59544	Cable and Wire, Electrical (Power, Fixed Installation)
DLA A-A-59551	Wire, Electrical, Copper (Uninsulated)
Navy A-A-59827	Topside Conduit (Flexible) and Conduit fittings, Electrical: Composite Based (Non-metallic)
UFC 3-350-03FA	Electrical Power Supply and Distribution
UFC 3-600-01	Fire Protection Engineering for Facilities
UFGS 26 12 19.20	Single-Phase Transformers
UFGS 26 12 19.10	Three-Phase Transformers
UFGS 33 70 02.00 10	Electrical Distribution System, Underground

Federal Specifications

W-C-375/3	Circuit Breakers, Molded Case; Branch Circuit and Service
W-S-865	Switch, Box (Enclosed), Surface Mounted
WW-C-566	Conduit, Metal, Flexible
WW-C-581	Class 1 Type A with Standard for Electrical Rigid Metal Conduit - Steel, UL 6

2.4 Non-Government publications

The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

American National Standards Institute (ANSI) Standards

ANSI 6	Standard for Rigid Metal Conduit. (Same as UL 6)
ANSI 467	Standard for Grounding and Bonding Equipment. (Same as UL 467)
ANSI 514	Fittings for Cable and Conduit. (Same as UL 514)
ANSI 651	Schedule 40 and 80 Rigid PVC Conduit. (Same as UL 651)
ANSI A14.3	Safety Code for Fixed Ladders
ANSI C2	National Electrical Safety Code (NESC). (Same as IEEE C2)
ANSI C62.11	IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV). (Same as IEEE C62.11)
ANSI C62.22	IEEE Guide for the Application of Metal Oxide Surge Arrester for Alternating Current Power Circuits. (Same as IEEE C62.22)
ANSI C62.22.1	Guide for the Connection of Surge Arresters to Protect Insulated, Shielded Electric Power Cable Systems (Same as IEEE 1299/C62.22.1)
ANSI C62.41	Recommended Practice on Characterization of Surges in Low-Voltage (1000V and Less) AC Power Circuits. (Same as IEEE C62.41)
ANSI C80	Rigid Steel Conduit – Zinc Coated. (Same as NEMA C80)
ANSI C119.1	Sealed Insulated Underground Connector System Rated 600 Volts. (Same as NEMA C119.1)
ANSI FB 1	Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies. (Same as NEMA FB1)
ANSI RN 1	Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit. (Same as NEMA RN 1)
ANSI S-97-682-2007	Standard for Utility Shielded Power Cables Rated 5 through 46 kV (Same as ICEA S-97-682-2007)

ANSI TC 6 & 8	PVC Plastic Utilities Duct for Underground Installation. (Same as NEMA TC 6 & 8)
ANSI Z535	Safety Alerting Standards. (Same as NEMA Z535)

American Society of Civil Engineers Standards

CI/ASCE 38-02	Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data.

American Society for Testing & Materials (ASTM) Standards

ASTM A48	Standard Specification for Gray Iron Castings.
ASTM B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors
ASTM C267-97	Standard Test Methods for Chemical Resistance of Mortars, Grouts, Monolithic Surfacings and Polymer Concretes
ASTM C478	Standard specification for Precast Concrete Manhole Section (AASHTO No. M199)
ASTM C579-96	Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes
ASTM C580-93	Standard Test Method for Flexural Strength and Modulus of Elasticity of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes
ASTM C858	Standard Specification for Underground Precast Concrete Utility Structures
ASTM C990	Standard Specification for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
ASTM D422	Standard Test Method for Particle-Size Analysis of Soils
ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort
ASTM D1056	Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber

ASTM D2444-93	Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)
ASTM F512	Standard Specification for Smooth-wall PVC Conduit and Fittings for Underground Installation
ASTM 1962	Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit under Obstacles
ASTM F2160	Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit

Institute of Electrical and Electronics Engineers (IEEE) Standards

IEEE C2	National Electrical Safety Code (NESC)
IEEE-48	Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV
IEEE 80	IEEE Guide for Safety in AC Substation Grounding
IEEE-100	The Authoritative Dictionary of IEEE Standards Terms
IEEE-386	Standard for Separable Insulated Connector Systems for Power Distribution Systems above 600V
IEEE-400.2	IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)
IEEE-400.3	Guide for Partial Discharge Testing of Shielded Power Cables in a Field Environment
IEEE-404	Standard for Power Cable Joints
IEEE-525	Cable Systems in Substations
IEEE-835	Power Cable Ampacity Tables
IEEE C62.11	IEEE Standard for Metal-Oxide Surge Arresters for AC Power Circuits (>1 kV).

IEEE C62.22	IEEE Guide for the Application of Metal Oxide Surge Arrester for Alternating Current Power Circuits
IEEE 1299/C62.22.1	Guide for the Connection of Surge Arresters to Protect Insulated, Shielded Electric Power Cable Systems
IEEE C62.41 (Formerly IEEE 587)	Recommended Practice on Characterization of Surges in Low-Voltage (1000V and Less) AC Power Circuits

Insulated Cable Engineers Association (IECA) Standards

ICEA S-94-964	Concentric Neutral Cables Rated 5-46 kV
ICEA S-97-682-2007	Standard for Utility Shielded Power Cables Rated 5 through 46 kV

International Electrotechnical Commission (IEC) Standards

IEC 60071-2	Insulation coordination Part 2: application guide.

National Electric Manufacturers Association (NEMA) Standards

RN 1	Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Steel Conduit
FB1	Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies
TC 2	Electrical Polyvinyl Chloride (PVC) Tubing (EPT) and Conduit (EPC-40 AND EPC-80)
TC 3	PVC Fittings for Use with Rigid PVC Conduit and Tubing
TC 6 & 8	PVC Plastic Utilities Duct for Underground Installation
TC 7	Smooth-Wall Coilable Electrical Polyethylene Conduit
TC 9	Fittings for PVC Plastic Utilities Duct for Underground Installation
TC 14	Filament-Wound Reinforced Thermosetting Resin Conduit and Fittings
NECA/NEMA 605	Recommended Practice for Installing Underground Nonmetallic Utility Duct

Underwriters' Laboratories (UL) Inc. Standards

UL 6	Standard for Rigid Metal Conduit
UL 467	Standard for Grounding and Bonding Equipment
UL 514	Fittings for Cable and Conduit
UL 651	Schedule 40 and 80 Rigid PVC Conduit

National Fire Protection Association (NFPA) Standards

NFPA-70	National Electric Code (NEC)
NFPA-70E	Electrical Safety in the Workplace
NFPA-780	Standard for the Installation of Lightning Protection Systems
NEC Hdbk	Art. 110.16, Flash Protection
NEC Hdbk	Art. 344.10, Rigid Metal Conduit: Type RMC
NEC Hdbk	Art. 280, Surge Arrestors, Over 1 kV

3. GENERAL

3.1 Definitions

Unless otherwise specified, electrical and electronics terms used in this specification, and on the drawings, shall be as defined in IEEE 100, *The Authoritative Dictionary of IEEE Standards Terms*.

In the text of this specification, the words “conduit” and “duct” are sometimes used interchangeably and have the same meaning.

In the text of this specification, "medium voltage cable splices" and "medium voltage cable joints" are used interchangeably and have the same meaning.

For the purposes of this specification, “FAA electrical line distribution systems (ELD)” shall be defined as:

FAA owned and operated electrical power distribution systems (underground or overhead) running from a power source to FAA facility load(s). An ELD may include some or all of the following: power cable; transformers; sectionalizers; switchpads; disconnect switches; manholes; hand-holes; utility poles; direct earth buried (DEB) cables; and underground duct banks. Intra-facility wiring, runway edge lighting cables, and FOTS and system cables, such as MALSR or ALSF loop cables are not included as part of ELD.

The demarcation point between an FAA ELD system and FAA facility premises wiring on an airport can be ambiguous. When in doubt, consult AJW-22, Power Services Group, Power Cable Program.

3.2 Submittals

Submittals are limited to those necessary for quality control (see Appendix E). Submittals marked A are required. For submittals marked B or C, the FAA task or contract specifier shall evaluate the contract for each kind, voltage, or type of submittal used on the project and make a determination as to whether the submittal is required. Examples given are not limited to those shown in parentheses:

“A” indicates that the submittal is required.

“B” indicates that the submittal is required, unless specifically deleted by the contract specifier.

“C” indicates that a submittal is not generally required because it is expensive and/or time consuming (i.e., a special case). If the submittal is required, the contract specifier shall show the required submittal on the submittals matrix (Appendix E) and in the contract documents (as a CLIN item).

a. Contractor-generated design data (ANSI C2 and FAA-STD-032, Para 3.1.13)
   1. Code analysis (e.g., voltage drops, clearance calculations, design arc flash study, etc) (ANSI C2) [A]
   2. Design assumptions and parameters (FAA-STD-032) [B]
   3. Test reports and findings (e.g., soil resistivity, load bearing, frost analysis, etc) [C]
   4. Design calculations (FAA-STD-032) [A]
   5. Contractor-generated design drawings or sketches. [A]
b. Cost estimates [A]
c. Medium voltage cable [A]
d. Medium voltage cable splices and joints* [A]
e. Medium voltage cable terminations* [A]
f. Conduits [A]
g. Duct construction materials (e.g., concrete, alternatives to concrete where approved, fills and layers, etc) [A]
h. Switch pads and sectionalizers [A]
i. Transfer switches (automatic and manual) [A]
j. Transformers [A]
k. Surge arresters [A]
l. Live end caps or protective caps [A]
m. Precast concrete structures [A]
n. Sealing Material [B]
o. Manhole frames and covers [A]
p. Hand hole frames and covers [A]
q. Cable supports (racks, arms and insulators) [A]
r. Protective devices and coordination study [A]
s. As-built arc flash hazard study. Required when an existing study is not available, or if modifications are being made to the existing ELD system. [A]
t. Electrical equipment factory test reports [A]
   1. Medium voltage cable factory certified test result report as per FAA-E-2793, Section 4.2 (includes meeting ICEA S-94-649, Sections 4.3.2.1 and 9.13). [A]
   2. Transformers [A]
   3. Switchgear, sectionalizers [A]
   4. Disconnects [A]
   5. Other applicable components [B]
u. Field acceptance checks and tests (see Appendix C) [A]
v. Arc-proofing test for cable fireproofing tape [C]
w. Cable installation plan and procedure (use cable installation plan only when pulling cable between manholes; do not use for pulling from pole riser to manhole only):
   1. Site layout drawing with cable pulls numerically identified [B]
   2. A list of equipment used, with calibration certifications [A]
   3. The manufacturer, type, and quantity of lubricant used on pull [B]
   4. The cable manufacturer and type of cable [A]
   5. The dates of cable pulls, time of day, and ambient temperature [C]
   6. The length of cable pull and calculated cable pulling tension (calculated value, not maximum value). A single generic table cable pulls may be submitted. [A]

7. The actual cable pulling tensions encountered during pull [A]
8. Certificates (tensiometer calibration, VLF tester calibration, etc) [A]

x. Cable splicer/terminator qualifications* [A]
y. Cable installer qualifications* [A]
z. Project design drawings [A]

*Note: The contractor shall provide the product drawings showing details of the connecting methods to be used, and a statement of the experience of the contractor in making connections on underground systems with the proposed product. Cable splicing/terminating personnel shall have a minimum of three (3) years continuous experience in terminating/splicing medium voltage cable. Products shall meet the latest editions of applicable standards as follows:

APPLICATION STANDARD (USE LATEST ISSUED)	LEVEL OF ACCEPTANCE
IEEE-404 Standard for Power Cable Joints	Meet or Exceed
IEEE-48 Standard for Cable Terminations	Meet or Exceed
ANSI C119.1 Sealed Insulated Underground Connector System Rated 600 Volts	Meet or Exceed
IEEE – 386 Standard for Separable Insulated Connectors	Meet or Exceed

3.3 Quality assurance

All work shall comply with the National Electrical Code (NEC) and IEEE C2/National Electrical Safety Code (NESC) for components and installation. To the maximum extent practicable, furnish products that are listed and labeled by a nationally recognized testing laboratory (NRTL) for the application, installation condition, and the environment in which the products are installed. Use of nonlisted components will not be allowed unless (1) it is demonstrated that listed components are not available, and (2) the FAA preapproves such components before installation. Approval shall be at the discretion of the FAA.

3.3.1 Quality plan

The contractor shall submit a Quality Plan in compliance with ISO 9001, *Quality Management Systems Requirements*. This plan will allow the FAA to identify the stages at which the FAA requires carrying out an inspection or witnessing a test. The plan shall cover all relevant stages of personnel qualification, design, coordination, supplier selection, manufacturers' acceptance testing, site inspection, site quality control testing, and commissioning. The plan shall identify relevant suppliers by name, components supplied, country of origin, and whether suppliers and supplied components are quality assurance certified.

3.3.2 Quality control

The quality of the equipment installed shall be controlled at the manufacturers' plants and at the project site to ensure that it meets the required specifications. The quality of civil engineering work, such as trenching, ducting, and other operations, shall be inspected by the FAA and approved after each major construction step. The contractor shall inform the FAA of manufacturing/shipping schedules and shall offer representatives of the FAA the opportunity to witness acceptance tests. These tests shall be performed on a statistically meaningful number of samples, as specified by FAA engineers. After receipt of equipment shipment and prior to

installation, the contractor shall subject equipment to a thorough visual inspection. An FAA representative shall be notified in advance and afforded the opportunity to be present and witness this step. Nameplates and markers shall be checked against the required specifications, and deviations brought to the FAA's attention. At the FAA's request, quality control checks, including acceptable electrical measurements (such as cable insulation resistance tests and surge protection leakage current measurements) shall be performed and reported. After the installation of cable systems is completed, acceptance/commissioning tests shall be performed.

All equipment and materials shall be subject to acceptance through the manufacturers' certification of compliance with applicable requirements when so requested. The requirements of this standard shall be considered as minimum requirements and shall not relieve the contractor of the responsibility to furnish and install higher grades of materials than specified when so required by the contract drawings and specifications. The installation shall conform to the most stringent requirements of the National Electrical Code (NEC), the local electrical codes, NFPA-70E, and applicable ANSI and IEEE standards, e.g., the National Electrical Safety Code (NESC), as well as other relevant guides and standards as listed in Section 2.

3.3.3 Qualifications of personnel

3.3.3.1 Designers

The design team shall have at least one engineer with significant experience in medium voltage design, review, and construction management. The engineer shall have worked with electrical power systems, and shall have designed electrical distribution systems whose reliability, maintainability, availability, and fault tolerance are of a similarly high level to those found in campus environments such as hospitals, life safety systems, and/or large computer and telecommunication facilities. The design engineer shall have the ultimate responsibility for the construction set (specifications, drawings, and cost estimates) and installation quality control. Drawings and engineering documents published by a non-FAA entity shall be signed by a registered professional engineer with knowledge and qualifications tailored to underground medium-voltage and low-voltage electrical distribution systems. Drawings and engineering documents published by a non-FAA entity shall be signed as approved by FAA Engineering Services or a representative of the PSG ELD/Power Cable Program upon design acceptance. Drawings ready for release for construction shall incorporate the project's design acceptance drawings by reference.

3.3.3.2 Installation Crew

Experienced personnel regularly engaged in underground electrical distribution system work shall perform the installation. Personnel exclusively or mainly trained in overhead line work, or low voltage facility wiring work, are not sufficiently qualified to install FAA medium-voltage underground electrical distribution systems. Workers shall be properly licensed where required by law. Only qualified personnel may work on electric circuit parts or equipment being installed.

A qualified person is one who has skills and knowledge related to the construction and operation of the FAA's electrical equipment and installations, and has received safety training to recognize and avoid the hazards involved. Management personnel shall be responsible for authorizing the qualified personnel to perform a task. Besides completion of Occupational and Safety and Health

Administration (OSHA)/FAA required electrical safety training for qualified personnel, those persons authorized to work on FAA ELD systems shall meet the requirements of a Qualified Person as mandated by OSHA and as discussed in NFPA 70E.

Along with training, personnel performing medium voltage work on FAA ELDs shall have: (1) the skills and techniques necessary to distinguish exposed live parts from other parts of electric equipment, including wire and cables, (2) the skills and techniques necessary to determine the nominal voltage of exposed energized electrical conductors or parts, (3) knowledge of the safe approach boundaries, work clearances, and voltages involved, (4) familiarity with construction and operation of equipment and the hazards involved, (5) familiarity with electrical safety related work practices and precautionary techniques, (6) familiarity with proper use of personal protective equipment (PPE), arc flash, insulating and shielding materials, (7) familiarity with the proper use of insulated tools and test equipment, (8) ability to make good decisions in determining the degree and extent of the hazard and the PPE and job planning necessary to perform the task safely, (9) familiarity with safety precautions associated with confined spaces, (10) knowledge of skills and techniques regarding how to select and use a voltage detector and phase meter, (11) familiarity with mechanical aspects of ELD installation work such as trenching, boring, excavation around existing utilities and structures, manhole rigging, and pulling cable, and (12) CPR training and basic training for emergency dispatch if an electrocution or confined spaces injury occurs.

Cable termination and splicing shall be performed only by experienced and qualified medium/high voltage electricians experienced in underground distribution systems. Before cable splices/terminations are made, the FAA may request an example splice and/or termination be made to demonstrate the electricians' qualifications. In order to qualify the splicer, this example splice and/or termination shall comply with the requirements of accessory manufacturers, and pass the requirements of IEEE standards 48, 386, and 404 with respect to partial discharge.

3.3.3.3 Inspectors and Testing Personnel

Inspectors of the FAA ELD distribution systems shall have knowledge and experience in quality control activities related to the inspection of cables laid in trenches such as are found at large campus environments such as hospitals, life safety systems, and/or large computer and telecommunication facilities; shall perform quality control activities during installation and preacceptance of medium and low-voltage switchgear and sectionalizers, protective devices, power distribution transformers, surge arrestor equipment, and motor control centers; shall review functional tests of electrical equipment and conduct inspection and preacceptance of electrical drawings, termination drawings, and cable schedules; and shall interpret the various drawings used in the projects for executing and recording the work.

Test personnel shall be qualified persons meeting the requirements stipulated in Appendix C.

3.3.4 Receiving, storing, and protecting

The contractor shall receive, store, protect, and handle products according to National Electrical Contractors Association NECA 1, *Standard Practices for Good Workmanship in Electrical*

Construction, and NECA/NEMA 605, *Recommended Practice for Installing Underground Nonmetallic Utility Duct.*

3.3.5 Sequencing and scheduling

The contractor shall:

1) Notify the FAA resident engineer to schedule inspection of each duct bank or duct bank segment before concrete is placed.

2) Provide the FAA resident engineer with reasonable notification before the anticipated date of acceptance testing of the newly installed replacement ELD system so that arrangements can be coordinated with the testing contractor.

3.3.6 Cable testing

3.3.6.1 Government-furnished cable

If government-furnished power cable is delivered to the contractor, the contractor shall test the cable on the reel and report electrical or physical cable defects within two weeks of cable receipt. If adequate cable lengths are unavailable for testing on the reel, a visual inspection shall be made and damage reported to the FAA. The required tests shall then be made immediately after unreeling. Defects discovered when installing the cable shall be reported to the FAA in accordance with the contract provisions.

3.3.6.2 Contractor-furnished cable

Single and multi-conductor power cables furnished by the contractor shall conform to the FAA specifications given in the Products section of this specification.

Cable shall meet the following minimum requirements:

a. Copper conductors.

b. Thermoplastic, thermosetting, or silicon rubber insulation.

c. Neoprene, polyethylene, or vinyl jacket for normal areas, and polytetrafluoroethylene (PTFE) (Teflon®) jacket in areas exposed to fuel, oil, solvent or chemical leakage, excessive groundwater, or extremely acidic soil.

d. For cables with rated voltages to 8 kV, cable insulation shall have a minimum continuous voltage withstanding capability of four times rated voltage (but not less than 150 volts). For rated voltages above 8 kV, insulation shall have a minimum continuous voltage withstanding capability of three times rated voltage. Cable voltage surge capabilities shall be 15 times rated voltage for voltages to 8 kV, nine times rated voltage for voltages above 8 kV through 15 kV, and seven times rated voltage for voltages above 15 kV through 25 kV. Whenever a cable is covered by applicable ICEA/NEMA specifications,

the cable shall pass the test requirements for such cable. In addition, the installed cable shall satisfy after-installation acceptance tests as specified below, and in Appendix C.

e. The pull strength of the completed cable(s) shall exceed the expected installation forces by a minimum of 50 percent.

3.3.6.3 Acceptance testing of new cable

Following installation, the contractor shall perform cable testing in the presence of the FAA. The contractor shall furnish necessary test instruments except where otherwise indicated in the project plans. Only currently calibrated instruments shall be used for cable testing. A laboratory approved by the measurement instrument manufacturer shall have performed instrument calibration. When conducting FAA-authorized third-party testing, offline partial discharge testing shall constitute the final acceptance test after completion of the installation.

Testing shall be completed on contractor-installed cable before connection is made to existing cables. If warranted, the FAA will test existing cables and provide the results to the contractor through the contracting officer prior to the contractor splicing or connecting cables he has installed to existing cables.

Certain acceptance tests classified as "destructive" by the IEEE shall only be conducted on newly installed cables. Such tests shall only be conducted within the test constraints given in Appendix C. Destructive tests shall not be performed on in-service (five years or older) power cables.

3.3.6.4 Acceptance testing of new power cables above 2000 volts

CAUTION
Zero-energy verification shall be accomplished before doing any work on de-energized medium-voltage equipment. In preparing for, and conducting, power cable tests, follow electrical safety procedures as outlined in FAA Order 6950.22.

New FAA underground, shielded, medium-voltage power cables rated 2000 volts and above shall be subjected, after installation but before connection to terminal equipment, to the following acceptance tests:

a. Continuity test for cable conductor, shield, and armor, using an ohmmeter type instrument. See FAA Order 6950.22 for parameters and test equipment.

b. Limited-voltage DC insulation resistance test using a Megger ™ type instrument. This test is formulated to apply and hold a DC voltage on the cable for a specified time, while measuring insulation resistance. See Appendix C for test description and processes.

c. One of the following tests:

a. Very low frequency (VLF, 0.1 Hz) AC high-potential withstand "pass/fail" test. The purpose of this type of test is not to ensure cable system future performance but simply to

reassure the construction team that the line is not grounded/shorted before energization. The test shall be performed after cable system installation, including terminations and joints, but before the cable system is placed in normal service. See Appendix C for test description and procedures.

b. If third-party partial discharge acceptance testing is authorized, a diagnostic 50/60 Hz, off-line partial discharge test. This test can localize and determine the severity of any defects in the new installation. Due to its requirements for specialized test equipment, signal processing software, and diagnostic skills, the test must be conducted by a third-party testing firm. The testing firm shall be a qualified contractor preauthorized by the FAA. See Appendix C for test description and procedures.

3.3.6.5 Acceptance testing of new power cables 600 volts and below

CAUTION
Zero-energy verification shall be accomplished before doing any work on de-energized medium-voltage equipment. In preparing for, and conducting, power cable tests, follow electrical safety procedures as outlined in FAA Order 6950.22.

All low-voltage (≤ 600 V) power cables shall measure not less than 50 megohms resistance between conductors, and between conductors and ground (see FAA Order 6950.22, *Maintenance of Electrical Power Cables,* Chapter 3, *Standards and Tolerances,* Paragraph 301, Table (see column heading labeled “NEW CABLE”). Measurements shall be taken at not less than 500 volts DC and not more than 1000 volts DC. This test does not constitute proof that the system is free from insulation defects but rather supplies evidence that the insulation was not damaged during the installation process.

3.3.6.6 Failure of cable under test

If the contractor-furnished cable fails to meet test requirements after installation, the contractor shall repair or replace, at his expense, the sections of cable proven defective.

If the government-furnished cable fails to meet test requirements after installation due to contractor’s faulty installation practices, the contractor shall repair or replace the defective sections of cable at contractor’s expense.

The installation contractor shall be responsible for retest costs if components are found to be substandard during acceptance test(s) as a result of contractor faulty installation practices.

4. PRODUCTS

4.1 Product options and substitutions

Alternative products may be substituted for product types that do not apply to the project. Consult with the airport authority and the local FAA project engineer.

4.2 Power cable

Single and multi-conductor power cables shall conform to the following FAA specifications:

a. FAA-E-2013 for single-and multi-conductor power cables used in exterior 600 volt applications.

b. FAA-E-2793 for single and multi-conductor power cables used in exterior 2,000 to 35,000 volt applications. Reference Section 4.2 for product factory certified test result reporting requirement.

4.3 Transformers

4.3.1 High voltage transformers (>600 volts)

4.3.1.1 Transformer design

ELD transformers are normally installed outdoors with proper clearance from structures. Transformers shall be “enviro-friendly” mineral-oil-filled or biodegradable electrical insulating and cooling-liquid filled. Choose less-flammable transformer liquids unless there is a specific requirement to do otherwise.

If the local site stipulates less flammable transformer liquids, the following section shall apply, use NFPA 70 for liquids having a fire point not less than 300 degrees C tested per ASTM D92 and a dielectric strength not less than 33 kV tested per ASTM D 877. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate. The fluid shall be a biodegradable electrical insulating and cooling liquid classified by UL and approved by FM Approvals® as "less flammable" fluids. The fluid shall meet the following properties:

- Pour point: ASTM D 97, less than -15 degree C,
- Aquatic biodegradation: EPA 712-C-98-075, 100%,
- Trout toxicity: OECD Test 203, zero mortality of EPA 600/4-90/027F, pass.

Silicon-filled and R-temp filled transformers shall not be used for less-flammable applications.

Transformers shall be pad mounted and of dead front design. If two-compartment transformers are required, obtain preapproval from the lead Engineering Services engineer or the Power Services Group, AJW-22. Aluminum core construction is acceptable. Due to associated safety hazards, transformers of the pole-mounted style shall not be used for ground-level FAA ELD applications.

4.3.1.2 Transformer bases and cabinets

Use stainless steel bases and cabinets in most applications, unless otherwise specified. The manufacturer's standard construction material is acceptable only in noncoastal and noncorrosive environments. For coastal/corrosive environments, ensure that front sill, hood, and tank base of single compartment transformers are corrosion resistant and constructed of stainless steel of not less than No. 13 U.S. gage, conforming to ASTM A167, Type 304 or 304L, unless otherwise indicated on the drawings. Base shall include any part of the pad-mounted transformer that is within 1.5 inches of the concrete pad.

In highly corrosive environments, the addition of totally stainless steel tanks and metering is required.

4.3.1.3 Warning signs and arc flash/shock hazard labels

For the enclosures of pad-mounted transformers having a nominal rating exceeding 600 volts, provide warning signs. After completion of arc flash hazard and shock analyses, label transformers with arc flash hazard and shock hazard warning information suitable to the particular installation.

4.3.1.4 Transformer losses

Transformers should meet the efficiency standards set forth in DOD's Unified Facility Guide Specification (UFGS) 26 12 19.20, *Single Phase Transformers,* Section 2.2.3.

4.3.2 Low-voltage transformers (<600 volts)

In FAA ELD systems, dry-type distribution transformers are used for buck boost applications or for short point-to-point distances for small loads of 600 volts or less. When used indoors, refer to FAA Specification FAA-C-1217, *Electrical Work, Interior.*

Transformers shall be mounted to allow for adequate ventilation (suitable for the local ambient temperatures).

4.4 Switchgear and sectionalizers

FAA ELD systems contain two types of switchgear: switch pads and sectionalizers. Both are fused devices used to de-energize equipment to allow work to be done and to clear faults downstream. More importantly, they isolate faulted line segments from a distribution system. These units shall be dead front-type units.

- Low-profile switch pads are typically used for single-phase applications.
- Sectionalizers are typically used for three-phase applications.

- Enclosures shall be outdoor rated or stainless steel, depending on location, meeting the requirements of ANSI C57.12.28. Use steel construction for typical installations. Use stainless steel construction for corrosive/salt environments.
- Pads or vaults shall be constructed of concrete or composite concrete-glass material. Concrete is preferred, but the latter may be used if approved by the FAA Resident Engineer and included on the drawings.
- Bases and cabinets shall be constructed of materials based on geographic location. Applications in dry locations shall employ steel; in wet locations, stainless steel.
    - Use stainless steel bases and cabinets in most applications. The manufacturer's standard construction material is acceptable only in noncoastal and noncorrosive environments. For coastal/corrosive environments, ensure that front sill, hood, and tank base of single compartment transformers are corrosion resistant and constructed of stainless steel of not less than No. 13 U.S. gage, conforming to ASTM A167, Type 304 or 304L, unless otherwise indicated on the drawings. Base shall include any part of the pad-mounted transformer that is within 1.5 inches of the concrete pad.
    - In highly corrosive environments, the addition of totally stainless steel tanks and metering is required.

4.5 Service disconnecting means

A main disconnect switch (MDS) ensures that electrical service to a facility can be completely de-energized for service or maintenance.

- MDSs shall be outdoor rated or stainless steel. Enclosures shall be NEMA 3R for typical applications, NEMA 4X for corrosive/salt environments.
- Pads shall be constructed of concrete or polymer concrete composite material. Concrete pads shall be no less than 6 in. thick. Concrete pads shall be brushed, chamfered, and graded for drainage. Expansion couplers should be considered in areas prone to frost heaving or ground settling.

4.6 Terminations and splices

4.6.1 Terminations

All power cable terminations rated above 4000 volts or with an outer shield shall be made with an authorized stress-relief device. Cable terminations shall be of a prefabricated design. Special care shall be exercised to provide the proper ratings and physical dimensions.

4.6.2 Splices

For medium voltage power cables (600 volts and above), use cold-shrink splice kits meeting ANSI/IEEE Std. 404 (for a 15 kV rating). For power cables 600 volts and below, use heavy-wall

self-sealing heat-shrinkable tubing meeting ANSI-C119.1-2006. Alternatively, use a poured epoxy splice, or any other splicing means approved by ANSI standards.

4.7 Overcurrent protective devices

- For FAA ELD systems, the preferred protective devices are fuses. In transformers, fuses shall be immersion-type, current-limiting fuses, accessible from the exterior of the equipment.
- The specific type and size of protective device shall be selected based on a protective device coordination study and short circuit analysis, and as provided in the drawings.

4.8 Underground duct systems

The configuration of an underground duct system shall depend on the specific application. Conduit types used within FAA duct systems shall be of the size, material, and type indicated on the contract documents. Size of conduit shall always be indicated on the drawings. All conduit material shall be UL listed and installed in accordance with UL listings.

4.8.1 Concrete-encased rigid nonmetallic conduit

Rigid nonmetallic conduit consists of two types:

1) Concrete-encased Schedule 40 PVC conduit is preferred for ELD duct systems. To reduce costs or for special applications, direct-buried Schedule 80 PVC conduit may be used in lieu of concrete encasement.

2) High-density polyethylene (HDPE) is a rigid nonmetallic conduit commonly used for boring.

4.8.1.1 PVC conduit

PVC conduit shall meet the requirements of UL651 – *Schedule 40 and 80 Rigid PVC Conduit,* NEMA TC 2 – *Electrical Polyvinyl Chloride (PVC) Conduit.* Solvent-welded socket fittings shall meet the requirements of UL514C – *Non-Metallic Fittings for Conduit and Outlet Boxes,* and NEMA TC 3 – *PVC Fittings for Use with Rigid PVC Conduit and Tubing*.

4.8.1.2 HDPE conduit

HDPE conduit shall meet the requirements of ASTM F2160-10/ASTM 1962-11/NEMA TC7.

4.8.2 Plastic-coated steel conduit

4.8.2.1 PVC coated RGS

Where situations warrant, such as when runway and equipment shutdown impacts are a consideration, PVC coated RGS may be used in lieu of concrete encased PVC duct. This substitution must be annotated on the drawings. Direct-buried rigid galvanized steel shall be

plastic coated. An acceptable alternative is RMC wrapped in half-lap fashion with pressure-sensitive 10-mil PVC-based corrosion protection tape.

PVC exterior coated, urethane interior coated, galvanized rigid steel conduit shall meet the requirements of NEMA RN 1 – *PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.*

4.8.2.2 Fittings and conduit bodies

Use 40 mil PVC exterior coated, urethane interior coated, zinc-plated, threaded, malleable iron meeting the requirements of UL514B – *Fittings for Conduit and Outlet Boxes,* and NEMA RN 1 – *PVC Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit*.

4.8.3 Direct buried rigid nonmetallic conduit

Direct-buried conduit shall be Schedule 80 PVC.

Solvent-welded socket fittings shall meet the requirements of UL514C – *Non-Metallic Fittings for Conduit and Outlet Boxes,* and NEMA TC 3 – *PVC Fittings for Use with Rigid PVC Conduit and Tubing*.

4.8.4 Rigid metal conduit (RMC)

Above-ground exterior conduit shall be rigid steel conduit.

Conduit used in exterior applications such as in an equipment rack shall meet the RGS requirements of UL6 – *Rigid Metal Electrical Conduit,* and ANSI C80.1 – *Rigid Steel Conduit, Zinc Coated*.

RMC fittings and conduit bodies shall meet the requirements of UL514B and ANSI/NEMA FB1.

Fittings: Follow NEMA TC 9, NEMA TC 14, and ASTM F-512.

4.9 Corrosion protection tape

Use pressure-sensitive, 10-mil-thick, PVC-based tape for corrosion protection of metal conduit and fittings.

4.10 Insulating bushings

Use NRTL-listed insulating bushings with 105º C rated insulation. Apply insulated protective caps to any unoccupied bushings. Dust caps shall not be used as substitutes for protective caps.

4.11 Grounding bushings

NRTL-listed, galvanized malleable iron, 150º C rated insulated throat grounding bushings with lay-in type ground cable lugs.

4.12 Sweeps

All sweeps shall be PVC-coated or tape-wrapped rigid galvanized steel (RGS).

Do not provide sweeps into a manhole. Vaults shall be considered for all transformer and switchgear applications wherever possible, eliminating the need for sweeps.

4.13 Duct spacers

Standard precast spacers (“chairs”) shall be used for duct support and alignment. Duct spacers shall provide a 3-inch separation between the conduit and the ground. There shall be a minimum of 3 inches of concrete on bottom, sides, and top of duct.

4.14 Duct plugs

In unused ducts, use soft, expansible gasket material compressed with non-metallic plates and bolts to produce a positive seal against water and gas.

4.15 Duct sealant and joint filler

Use expandable foam duct sealant kits to prevent water and gas from entering manholes, vaults, or structures.

Use premolded joint filler to fill holes in and around conduit to keep rodents out of the ELD system. Use closed-cell expanded neoprene joint filler conforming to ASTM D1056 – *Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber*.

4.16 Underground duct and cable warning tape

Furnish detectable underground warning tape for underground duct banks. Use aluminum-backed, 0.005 inch thick, underground warning tape with a red background color. Lettering shall be black and indicate the type service buried below:

"CAUTION BURIED ELECTRIC LINE BELOW"

Use tape width appropriate for the burial depth:

A. Three-inch wide tape for up to 18 inches depth.
B. Six-inch wide tape for up to 24 inches depth.

All direct buried cable shall be marked with extrusion-laminated underground marking tape. Tape shall be a minimum of six inches (6”) wide and shall run continuously in the cable trench six inches (6”) below the surface or as indicated on the project plans. Tape shall be bright red, and constructed of solid 100% pigmented plastic, and not an ink-coated plastic.

4.17 Pull wires and tape

For spare ducts, specify ¼ inch pull tape having a minimum tensile strength of 400 pounds for non-metallic conduit. The FAA project engineer may specify a larger or more specialized pull tape (impregnated lubricant, distance marking, etc).

For ELD circuits that include raceways within vaults or other locations, raceway measuring/pulling tape may be used. Tape shall have permanently printed measurements in one-foot increments and minimum 1200 lb average breaking strength.

4.18 Precast electrical manholes and hand holes, accessories

4.18.1 Manholes and hand holes

Precast reinforced concrete electrical utility structures shall be of the size and shape as detailed on the drawings in conformance with ASTM C-858 – *Standard Specification for Underground Precast Concrete Utility Structures*. Electrical manholes are typically 4’ long, 4’ wide, and 4’ high, or as shown on the drawings. Electrical manhole sections shall conform to ASTM C-478.

4.18.1.1 Manholes/hand hole structures, frames, and lids

4.18.1.1.1 Airports handling aircraft with maximum departure/takeoff weight of 30,000 lb and above--For airports with a design aircraft maximum departure weight of 30,000 lb and above,* manholes/hand holes, frames, and lids located within the airport runway/taxiway safety areas (RSA/TSA) shall be of the aircraft-rated type, designed and certified for 100,000 lb (45,000 kg) wheel loads with 250 psi (1.72 MPa) tire pressure. (Refer to FAA Advisory Circular 150/5320-6, Appendix 3, *Design of Structures for Heavy Airplanes*). Clearly indicate on the drawings underground utility structures that will be subject to aircraft loading. For planned future-expansion projects where manholes and hand holes are projected to fall within RSA and TSA boundaries, those structures shall be aircraft rated.

Outside the RSA/TSA, H-20 highway-rated manhole and hand hole components are permitted, provided an adequate proof load safety margin for the casting is met. First, live loading shall meet basic H-20 loading requirements per A.A.S.H.T.O. HB-17, *Standard Specifications for Highway Bridges*. The live load shall be that loading which produces the maximum bending and shear moments in the structure. H-20 design wheel load is a minimum of 16,000 pounds, or 80 psi. For the safety margin, the casting must meet AASHTO M306, which requires that it pass a proof load test of 40,000 lb applied on a 9x9-in. pad in the center of the casting. H-20 rated utility structures that do not meet the above requirements shall not be used.

Manholes that consist of two sections shall be joined at the site to provide a watertight joint using a preformed flexible sealant as specified in ASTM C-990. A twelve inch (12 in.) diameter sump, four inches (4 in.) deep, shall be cast in the center of the manhole floor and supplied with a cast iron cover.

Manhole floor shall be cast integral with walls to form the bottom ring. Furnish a keyed joint between the bottom ring and top ring. Manhole roof shall be a one-piece concrete cap.

*Airports handling dual-wheel-landing-gear aircraft up to 60,000 lb maximum departure weight are permitted to use highway-rated manholes/hand holes and components in the RSA/TSA because the wheel load is distributed over four tires (60,000 ÷ 4 = 15,000 lb). Adequate safety margins must be met through proof loading. Refer to the H-20 loading requirements specified above.

4.18.1.1.2 Airports handling aircraft maximum departure/takeoff weight of 30,000 lb or below-- For airports with a design aircraft maximum departure weight of 30,000 lb or below (60,000 lb if dual-wheel landing gear), manholes/hand holes, frames, and lids located both within and outside the airport runway/taxiway safety areas (RSA/TSA) shall be of the highway-rated type, provided a safety margin for the manhole casting is added. Live loading shall be for H-20 loading with adequate safety margin as described in Section 4.18.1.1.1 above. Clearly indicate on the drawings underground structures that will be subject to aircraft loading.

For planned future-expansion projects where manholes and hand holes are projected to fall within RSA and TSA boundaries, and the expansion is expected to accommodate heavier aircraft with maximum departure/takeoff weight of 30,000 lb and above (60,000 lb if dual-wheel landing gear aircraft), those structures shall be aircraft rated. Concurrently, existing non-aircraft-rated manhole/hand hole structures throughout the airport's RSA/TSA areas shall be retrofitted with aircraft-rated structures and components.

Outside the RSA/TSA in non-vehicular traffic areas, other types of enclosure structures (e.g., polymer concrete, nonreinforced concrete, or other) may be used provided (1) they meet ANSI Tier 22 (design/ test = 22,500/33,750 lb) specifications, and (2) have been approved by the FAA resident engineer.

Manholes that consist of two sections shall be joined at the site to provide a watertight joint using a preformed flexible sealant as specified in ASTM C-990. A twelve inch (12 in.) diameter sump, four inches (4 in.) deep, shall be cast in the center of the manhole floor and supplied with a cast iron cover.

Manhole floor shall be cast integral with walls to form the bottom ring. Furnish a keyed joint between the bottom ring and top ring. Manhole roof shall be a one-piece concrete cap.

Manhole markings--Identify electrical power manholes and hand holes by "FAA Power" markings cast in the steel cover, or so identified with a die stamped, nominal one sixteenth inch (1/16") minimum thickness copper plate, brazed or fastened to the cover with a minimum of two 10-32 brass machine screws.

4.18.2 Manholes accessories

Frame and lids--Use heavy duty cast iron manhole frame with solid lid. Lid may be spring loaded. Alternatively, lid may consist of partitioned aircraft-rated lid segments, each segment capable of being lifted separately, facilitating easier and safer access.

Racks--Cable racks and cable support arms shall be furnished in the quantities and locations indicated by the drawings for each manhole. Racks shall be made of nonmetallic material (for example, PVC, plastic, or UL-rated glass-reinforced nylon). Saddle arms shall be as per the approved project drawings. Splices and cables shall be attached to cable racks.

4.19 Grounding cables

Depending on the application, ELD exterior grounding conductors shall be of the type and size required by applicable sections of FAA-STD-019.

a. For equipment grounding conductors, use 4/0 AWG bare stranded, soft temper copper cable per ASTM B 8, *Standard Specification for Concentric-Lay Stranded Copper Conductors.*

b. For guard wire, use 1/0 AWG bare copper, stranded.

c. For bonding conductors, use No. 2 AWG bare copper, stranded.

4.20 Ground rods

Ground rods (“grounding electrodes”) shall be three quarter inch (3/4”) by ten foot (10’) long copper or copper-clad steel.

4.21 Weather heads on risers, drip loops

Risers feeding FAA owned underground distribution systems shall have weather heads installed. Each weather head shall have drip loops that loop no less than 6” below the weather head.

4.22 Electrical equipment enclosures

Bases and cabinets of electrical equipment shall be constructed of materials suitable to their geographic location.

Typical, dry environments--For typical dry conditions, mild steel bases and enclosures may be used. These provide protection against rain, sleet, and snow in outdoor applications.

Corrosive or wet environments—For typical wet (or wet and salt-corrosive) conditions, use stainless steel bases and enclosures.

Use stainless steel bases and cabinets in most applications. The manufacturer's standard construction material is acceptable only in noncoastal and noncorrosive environments. For coastal/corrosive environments, ensure that front sill, hood, and tank base of single compartment transformers are corrosion resistant and constructed of stainless steel of not less than No. 13 U.S. gage, conforming to ASTM A167, Type 304 or 304L, unless otherwise indicated on the drawings. Base shall include any part of the pad-mounted transformer that is within 1.5 inches of the concrete pad.

In highly corrosive environments, the addition of totally stainless steel tanks and metering is required.

4.23 Equipment vaults and pads

Follow the drawings for specification and construction details of equipment foundation support structures. Specific applications are as follows:

4.23.1 Concrete vaults

For low-profile single phase transformers, use precast concrete vaults to facilitate ease of transition from duct bank system to transformer termination points. Concrete shall meet or exceed a 28-day compressive strength of 3,000 psi.

4.23.2 Concrete pads for transformers

Foundations of poured concrete pads for larger size transformers (>50 kVA) shall have a minimum thickness of 6 inches, unless otherwise specified on the drawings. Thicker pads than 6 in. may be considered in areas subject to frost heave. Concrete shall meet or exceed a 28-day compressive strength of 3,000 psi.

4.23.3 Concrete pads for equipment racks

Foundations of poured concrete pads shall have a minimum thickness of 6 inches, unless otherwise specified on the drawings. Thicker pads than 6 in. may be considered in areas subject to frost heave. Concrete shall be chamfered, brushed, and graded for drainage. Expansion couplers on protruding conduits should be considered in areas prone to frost heaving or ground settling. Concrete shall meet or exceed a 28-day compressive strength of 3,000 psi.

Prefabricated concrete pads with cutouts for cables can be used where frost heave is prevalent. Arrange for lift equipment to place the pads. Install cables in conduit and leave a slack length of cable in case the pad is displaced upward by ground frost.

4.23.4 Composite polymer concrete equipment pads

If approved by the FAA Resident Engineer and included on the drawings, lightweight polymer concrete flat pads and box bases that provide sufficient strength-to-weight ratios may be used. These units have cutouts and preinstalled mounting hardware. No extra equipment is required to lift the pads into position.

Composite pads/boxes shall be composed of cement mortar reinforced by alkali resistant glass fibers. The material shall incorporate a minimum of 4 percent by volume of alkali resistant glass fibers.

Composite pads/boxes shall meet or exceed a compressive strength of 11,000 psi per ASTM C579-96, a flexural strength of 1,800 psi per ASTM C580-93, and a modus of elasticity of 2,900,000 psi per ASTM C580-93. Composite pads/boxes shall also pass chemical resistance and impact resistance tests in accordance with ASTM C267-97 and D2444-93.

Composite pads/boxes shall not warp, support flame, rust, or be UV degradable. They shall have a waffle bottom design to permit loose earth to fill bottom voids to level and stabilize the pad. The pad/box shall not be affected by asphalt, road salts, fertilizers, transformer oil, other common chemicals, weather, sunlight or other normal service conditions to which they may be exposed. Composite pads/boxes shall be capable, with equipment installed, of withstanding temperature variations of -40 degrees C (-40 degrees F) to +65 degrees C (149 degrees F) without cracking, splitting, or deforming. They shall not be designed and constructed so as to trap or hold water and shall be able to withstand repeated freeze-thaw cycles.

4.24 Bollards

Bollards shall be used only where it is necessary and/or as required by the airport authority to protect electrical equipment and enclosures from field vehicle damage or other mechanical damage. Bollard use and placement shall be as specified on the drawings or as determined by final location of equipment. Unless otherwise specified, use 4-in. diameter steel pipe filled with concrete. Bollards shall be placed 3 ft deep and extend 4 ft above ground level. Premanufactured plastic jackets shall cover each bollard.

5. EXECUTION

5.1 Scheduling of work

Airport runways must remain in operation during certain periods. Contractors shall proceed in a manner that produces minimum disruption to the FAA and airport operations. During construction activity, contractors shall coordinate work through the FAA Resident Engineer, the airport authority, air traffic control tower, airport security, and other contractors as defined by the contract documents. Work performed within the RSA/TSA of an active runway may require runway/taxiway closing. Advance notice of proposed work near an active runway shall be required to be given by contractors to the FAA.

5.2 Existing FAA buried cable and ducts

5.2.1 FAA documentation

The contract documents define the drawing format used by the FAA to record the location of buried cable and ducts. The contractor shall use the FAA format during the course of work to ensure the accurate location of the new installations as described on the FAA drawings. The contract documents shall include copies of FAA drawings for the area of work. Contract drawings and engineering documents published by a non-FAA entity shall be approved by the FAA project engineer.

5.2.2 FAA marking of known buried cables and ducts

All known FAA power and control cables leading to and from an operating facility will be marked in the area of work by the FAA for the information of the contractor before starting work. The FAA will mark these cables once for the contractor. It shall be the contractor's responsibility to maintain these markings throughout the course of the project. Airport mowers may be expected to be in use by airport personnel throughout the duration of the work, keeping markers visible. FAA is responsible for marking FAA cables ONLY. The contractor shall be responsible for marking other cables and utilities in the work areas through a third party location service.

5.2.3 Other buried cables, ducts, piping and items

Locating utilities--The contractor shall be responsible for contacting the utilities prior to starting work and for confirming the location of existing utilities and other items that may be buried in the area of work. Along an area suspected of having utilities of any sort, the contractor shall hand dig or use other authorized low-impact digging system. The airport authority shall be contacted to locate those items owned or known by the airport to exist.

Avoiding buried structures--The contractor shall take precautions to protect existing underground (buried) items including but not limited to; fuel tanks, water lines, cables, ducts, and structures.

Buried items shall be protected from damage for the duration of work. The contractor shall immediately repair, with equal material by skilled workmen, those items damaged by the contractor or subcontractor.

Procedure for making repairs during installation--Prior authorization from the FAA shall be obtained for the materials, workers, time of day or night for making repairs, method of repairs, and permanent repairs the contractor proposes to make. In the event of inadvertent damage, the contractor shall immediately stop work and notify the FAA and utility when appropriate. Repair work shall be inspected and authorized by the FAA with the concurrence of the affected utility company, airport, or other owner(s) of the damaged item(s).

Cables to be abandoned—When a DEB cable is identified to be abandoned, where possible it shall be disconnected and left in place. Unless otherwise directed, cut the cable, armor, and ground wires back 10 feet at each end. Where possible, exothermically weld the cable ends to ¾" by 10' ground rods 12 in. below grade. Document the section that was cut back as "abandoned" on as-built drawings.

When a cable in duct is identified to be abandoned, ground the cable, armor, and ground wires at both ends. Where possible, exothermically weld the cable ends to ground rods 12 in. below grade. Document the section that was cut back as "abandoned" on as-built drawings.

Replaced cables—Replaced cables shall trace the same routing path as previously employed. Should there be a need to divert from the previous route, careful planning shall be exercised, especially in areas where utilities, communications, control, and NAVAIDS systems such as Glide Slope and Localizer facilities are installed or planned to be installed in the future. Approval from the office of primary interest is required.

5.3 Safety during construction and testing

All necessary site work included in the overall scope of work, from delivery to site to final authorization, shall undergo a safety risk assessment. A detailed, site-specific, Safety Risk Assessment shall be submitted by the contractor to FAA for final authorization no fewer than 3 weeks prior to commencement of on-site work. During construction, installation, and testing, the contractor shall comply with the safety rules of FAA (FAA Order JO 3900.XX, FAA Advisory Circular AC 150/5370-2) and those dictated by OSHA (Part 1926), NEC, ANSI/IEEE, and ANSI C2 (the NESC). The contractor shall be responsible for the implementation of FAA-authorized items in the Safety Risk Assessment document.

5.4 Excavation and trenching

The following are general excavation and trenching requirements. Note paragraphs that follow for particular requirements for either (1) direct earth buried cables, or (2) underground duct cables.

5.4.1 Depth requirements

IEEE ANSI C2 (part of the National Electric Safety Code) specifies the minimum legal depth requirements for medium-voltage power cable during installation. Tailoring organizations shall evaluate site-specific requirements and follow the following standards in order of precedence: (1) IEEE ANSI C2, then (2) paragraphs below, then (3) local standards if applicable.

Conduits shall meet the following minimum standards:

a. Unless otherwise specified due to soil conditions or other circumstances, cables, conduits, and ducts shall be buried to the minimum depth to their top as specified by the following paragraphs b through g. In the event that achieving the minimum depth is not feasible, follow the direction of the FAA Resident Engineer.

b. Top of direct-earth buried (DEB) conduit or cables under 600V shall be a minimum of twenty four inches (24”) below finished grade, per ANSI C2 (see Table I), unless local conditions and regulations require deeper burial, in which case the contractor shall advise FAA about these conditions and regulations before proceeding with the construction.

TABLE I. Burial depths (source: ANSI C2)

Voltage (phase to phase)	Depth of burial	
	(mm)	(in.)
0 to 600	600	24
601 to 50,000	750	30

c. Top of direct-earth-buried conduit or cables over 600V shall be a minimum of thirty inches (30”) below finished grade, per ANSI C2 (see Table I), unless local conditions and regulations require deeper burial, in which case the contractor shall advise FAA about these conditions and regulations before proceeding with the construction.

d. If finished grade has not been established before the cable trenches are excavated, it is the contractor’s responsibility to determine what the final finished grade elevation will be and excavate the trench deep enough to meet the depth requirements at the end of the project.

e. Underground concrete-encased duct, and duct consisting of PVC Schedule 80, HDPE, or RGS conduit, shall be installed so that the top of the conduit is buried at not less than twenty-four inches (24”) below finished grade.

f. Additional requirements for all ducts: concrete-encased duct, rigid steel conduit, or PVC conduit shall be installed so that the top of the conduit is buried as follows:

1. When installed under runways, not less than four feet (4’) below the bottom of paving, or as specified by the airport authority,

2. When installed under taxiways, not less than four feet (4’) below the bottom of paving, or as specified by the airport authority,

3. When installed under other paved areas, in accordance with Table I or as required by the local jurisdiction.

4. For railroads and state-owned highways, at the minimum depth below grade as specified by those entities.

5. Where local conditions require unusually deep burial of ducts, contractor shall discuss the situation with the FAA project engineer and obtain preauthorization.

g. In northern climates where deep trenching is cost prohibitive, use a standard depth of not less than 24 inches (24") from top of duct, cable, or conduit to finished grade.

h. Cables shall not be direct buried under paved areas, runways, taxiways, roadways, railroad tracks, or ditches. Where cables cross under roads or other paving exceeding 5 feet in width, such cables shall be installed in rigid steel conduit, concrete-encased PVC, steel conduit, or high-density polyethylene (HDPE) conduit, as defined by the contract documents. Where cables cross under railroad tracks, such cables shall be installed in accordance with the requirements of the railroad authority. Cables under railroad grades may be installed in reinforced concrete-encased ducts, rigid galvanized steel sleeves, or HDPE conduit, subject to the requirements of the railroad authority. HDPE must be of sufficient crush strength to withstand expected static and dynamic loads over the expected lifetime of the cable without deformation. For directional boring under railroad and roadway grades, standard dimension ratio (SDR) 11 or 9 shall be used depending on conditions and conduit diameter. The SDR of a conduit is defined as the ratio of the average conduit diameter divided by the minimum wall thickness. Damage to conduit coatings shall be prevented by providing ferrous pipe jackets or by predrilling. Ducts shall extend at least 1 foot beyond each edge of paving and at least 5 feet beyond each side of railroad tracks.

i. Where direct burial cable transitions to duct-enclosed cable, direct-burial cables shall be centered in duct entrances, and a waterproof nonhardening mastic compound shall be used to facilitate such centering. Cables may be pulled into duct from a fixed reel where properly sized rollers are provided in the trench. Where cuts are made in paving, the paving and subbase shall be restored to their original condition. Where cable is placed in duct (for example, under paved areas, roads, or railroads), ducts shall be made to slope in order to drain.

5.4.2 Survey requirements

5.4.2.1 Recording of data

The ELD project record shall consist of (a) information entered in computer-aided design and drafting (CADD) systems, (b) manual plotting onto the FAA drawing set, (c) Global Positioning System (GPS) data, (d) Geographic Information System (GIS) information or databases, and/or (e) other appropriate documentation as set forth in the contract documents.

Placement of markers--Drawings shall record positions of markers placed in or on top of direct earth buried (DEB) power cable trenches, and at duct bank manholes and hand holes. The markers shall be identified on the drawings by a small circle with a "P" in the center for power cable, "C" for control/fiber cable, "R" for coaxial cable, "S" for special purpose points, and "T" for telecommunications.

DEB cable--DEB cable trenches shall be identified on the drawings with text boxes pointing to the trench indicating what is in the trench. If there are several cables in the trench, each cable shall be called out. Power cables shall be identified by the actual working voltage of the cable and not by the cable insulation rating. Anything unusual, peculiar, or unique about the cable runs shall also be called out in the drawings.

Duct banks--Duct banks shall be plotted on the drawings. Duct banks that are installed for future use shall have text boxes pointing to them indicating that they are future-use duct banks. In the case of a duct bank where the duct bank is not a straight line between the manholes or hand holes, enough markers of the type specified herein shall be installed to accurately depict the routing of the duct bank.

Manholes, hand holes, and splices--Manholes shall be identified on drawings by a small square with an "MH" in the center. Hand holes shall be identified by a small square with an "HH" in the center. Where manhole and hand hole numbers are provided on the contract drawings, they shall also be called out on the completed cable drawing. Splices made in manholes and hand holes shall be shown on the cable drawings.

Abandoned cables--The contractor shall provide data on the types and locations of abandoned cables in places where they affect the excavation of new trenching, such as at points of intersection with other structures, including runways, taxiways, concrete pads, utility pathways, roads, etc. This information shall be included on the drawings.

5.4.2.2 Survey points

The contractor shall record the survey point of each manhole using GPS coordinates. At each major change of direction of the cable circuit, a manhole shall be present and its location surveyed and recorded. Surveying and data gathering for this purpose shall be completed before a trench or structure is backfilled.

If for some reason the cable path deviates from a straight line between manholes and is not capable of being traced using tracing equipment, the deviation should be recorded as a survey point on the drawings for future reference. Where the cable terminates to a building, a transformer, an antenna, a light bar, an outside demarcation cabinet, switch rack, or other similar device, the survey shall include the four corners of the device or facility where it terminates. A tolerance of plus or minus five inches (± 5") will be acceptable for describing the cable path.

Special-purpose points--Special-purpose points may be used to indicate points such as splices or entrances to duct banks in records and on the drawings. Special-purpose points shall be accompanied by a text box to describe the function of the specific point.

5.5 Underground duct systems

Power distribution cables at FAA installations shall be installed in underground duct systems. Unless preauthorized per the drawing set and construction specifications, direct earth burial (DEB) of power distribution cables is prohibited. If preauthorized, any DEB construction shall meet the requirements in Section 5.6.

5.5.1 Preparation and excavation for underground ducts

In preparing to install underground ELD ducts, contractor shall meet the industry standards given in this section. Contractor shall also work with FAA to contact the owner for their requirements, coordinating underground ELD duct work to avoid interference with other airport projects and existing utilities. The contract specifier shall work with the Power Cable (ELD) Program Office to ensure coordination of work with other FAA programs that may have an interest in using the same duct system or trench.

The contractor shall excavate trenches for underground ducts as follows:

a. To the depth specified in paragraph 5.4.1c.

b. Install underground duct bank systems according to the NEC, the NESC, NECA/NEMA 605 (*Recommended Practice for installing Underground Nonmetallic Utility Duct),* ANSI/IEEE C2, and other requirements in this section.

c. Verify routing and termination locations of duct banks before excavation for rough-in.

d. Verify that field measurements are as shown on the drawings.

e. Position trench so concrete envelope of duct banks shall have the following minimum horizontal and vertical separations from parallel or perpendicular runs of other utility pipes or conduits (Table II). Note: Measurements are guides only; check with local authorities and the owner for their specific requirements.

f. Make trenches of sufficient width to receive work to be installed and provide specified concrete coverage on sides.

g. Conduit or castings required under roadways or railroads shall be installed by boring. Jacking of conduit is not allowed. Conduits bored under roads off airport property shall be a minimum of thirty inches (30”) below finished grade, or as required by the local jurisdiction.

h. Backfill excavations for duct banks and manholes in 6-inch layers using excavated soil. Remove roots, rocks and sharp objects. Furnish coarse sand as required for additional backfill material.

i. Moisture condition backfill soil and compact to 95% of maximum density under paved areas and 90% of maximum density under unpaved areas.

j. Overfill excavations to allow for settling.

k. Firmly tamp backfill in the separation area.

l. Restore area.

TABLE II. Spacing of power cable ducts from other utilities.

UTILITY TYPE	PARALLEL LINES	PERPENDICULAR CROSSINGS
Water	36 inches horizontal separation	24 inches
Gravity Sewer	36 inches horizontal separation	24 inches
Force Main Sewer	36 inches horizontal separation	24 inches
Storm Drain	36 inches horizontal separation	24 inches
Natural Gas	60 inches horizontal separation	24 inches
Steam or Hot Water	60 inches horizontal separation	24 inches
Open Communications	24 inches horizontal separation of tamped soil or 3 inches of concrete	12 inches vertical separation of tamped soil or 3 inches of concrete
Secure Communications	36 inches horizontal separation of tamped soil or 6 inches of concrete; verify case-by-case with FAA office of primary responsibility.	24 inches vertical separation of tamped soil or 6 inches of concrete; verify case-by-case with FAA office of primary responsibility.
Electrical	12 inches horizontal separation of tamped soil or 3 inches of concrete	12 inches vertical separation of tamped soil or 3 inches of concrete

5.5.1.1 Connecting requirements for HDPE conduit running through and emerging from a bore

When placing HDPE conduit underground through a bore, use one continuous length of flexible HDPE conduit. In instances where a continuous run of conduit is not possible, individual sections shall be joined using heat-welded (fused) connections. After emerging from a bore, the HDPE will typically terminate in a manhole at both ends.

To join lengths of conduit together after emergence from a bore, follow these procedures:

a. If the emerging HDPE conduit is to be joined to PVC conduit, the HDPE conduit section shall be run into the bell end of the PVC conduit and cemented using a special bonding agent (Table III) (see Appendix F for a sample two-part bonding product). Adhesives typically used for connecting PVC segments are not of sufficient strength for HDPE-to-PVC transitions and shall not be used. Alternatively, the HDPE conduit may be connected to a PVC coupling on the end of a length of PVC conduit. The point of

transition shall then either be (1) encased in concrete together with the remaining run of PVC, or (2) direct earth buried, depending on the type of burial method used for the rest of the run.

b. Connection details involving HDPE conduit shall be shown on the drawings.

TABLE III. Adhesive minimum pullout-force requirements for bonding HDPE to HDPE and HDPE to PVC conduit materials.

Conduit Diameter	Polyethylene Conduit to PVC Standard Coupling	
	Coupling length	Pullout Force
1 inch	2 ⅛ inch	760 lb
1 ½ inch	2 ⅜ inch	1,140 lb
2 inch	2 ½ inch	1,520 lb
4 inch	3 ¾ inch	4,560 lb

5.5.2 Backfilling

Backfilling material and procedures depend on the design used, whether concrete-encased duct or direct buried conduit. Consult FAA Advisory Circular AC 150/5370-10 for construction details.

Trenches shall be completely backfilled and tamped level with the adjacent surface. When necessary to obtain the desired compaction, backfill material shall be moistened or aerated. When sod is to be placed over a trench, backfill shall be stopped at a depth equal to the thickness of the sod to be used. Excess excavated material shall be removed in accordance with the contract documents.

5.5.3 Restoration

Restoration shall be in accordance with local airport authority requirements, or as otherwise stated in the contract statement of work. Where it has been removed, soil shall be replaced as soon as possible after the backfilling is completed. All areas disturbed by the trenching, storing of dirt, cable laying, pad construction, and other work shall be restored to the original condition.

Restoration shall include the necessary grading, seeding, sodding, sprigging, or hydroseeding as required to restore the disturbed area to match the adjacent area. Where trenching cuts through paved areas, the surface shall be properly backfilled and resurfaced with paving similar to the original paving or concrete as the drawings specify.

Resurfaced areas shall be level with original paving, free from cracks, and capable of withstanding full traffic loads without settling or cracking. The contractor shall be held responsible for maintaining all disturbed and restored surfaces until final acceptance by the FAA.

5.5.4 Duct installation

Cable duct banks shall be installed outside of the airport runway/taxiway service areas (RSA/TSA), as well as ILS critical areas, to the greatest extent possible. Where trenching is required through an RSA or TSA area, place the manholes to the farthest extent possible outside the RSA and TSA while still maintaining standard spacing and directional change requirements as noted elsewhere in this specification. For locations of RSA/TSA/ILS areas, consult with the FAA Resident Engineer. (See also FAA Order JO 6750.16, *Siting Criteria for Instrument Landing Systems*, and FAA Advisory Circular 150/5300-13, *Airport Design*, particularly Chapter 6, *Navigation Aids [NAVAIDs] and On-Airport Air Traffic Control Facilities [ATC-F]*).

When there is an immediate change in direction of a duct system, a manhole or hand hole shall be installed. Any gradual change in direction (e.g., a gradual arc of the duct) shall require the approval of the resident engineer prior to installation.

5.5.5 Manhole and hand hole installation

5.5.5.1 Manhole installation

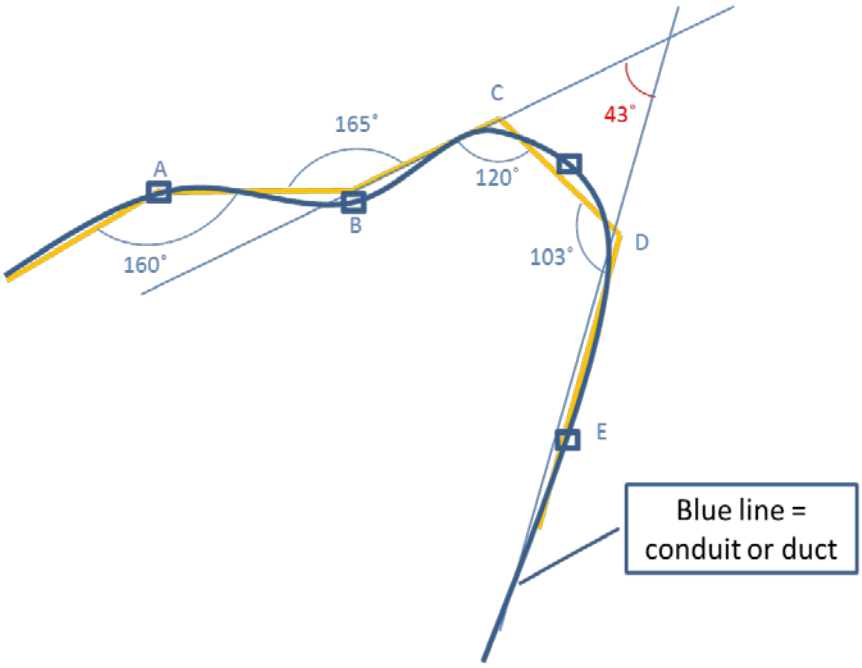
Install manholes every 600 feet. Where there are long continuous, straight runs, manholes may be placed up to 1200 feet apart with preapproval of the project engineer. When there is a planned change in direction of the conduit between manholes of greater than 45 degrees (cumulatively within a run), an additional manhole shall be installed in place of the directional change (Figure 5.5.5.1-1).

The top of the completed manhole shall be set above finish grade in unpaved areas to prevent water from ponding on the manhole. Place the top of the manhole 2 inches (2”) above grade, plus or minus 1 inch (1”). Grade the backfill material downward and away from the manhole. A one-eighth-inch (1/8”) per foot fall from the manhole top to finish grade, ten feet (10’) from each edge of the manhole is recommended.

The manhole lower half shall be set on a four-inch (4”) bed of crushed stone on undisturbed earth. Add a layer of geotextile fabric between the gravel and earth to enhance soil stability and prevent settling of the manhole. The contract drawings will define any additional requirements where soil bearing capacities are an issue or concern.

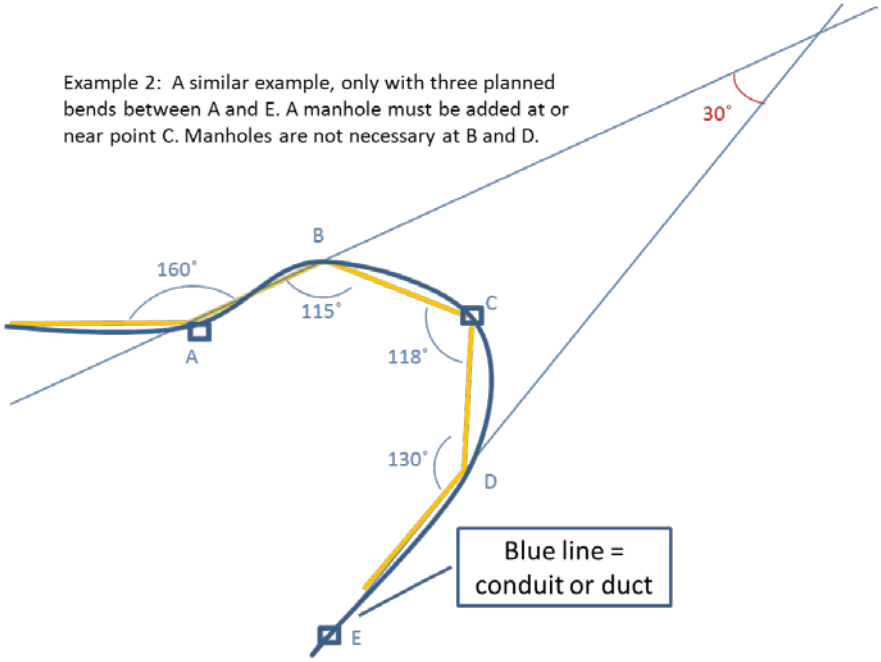
Backfill around the manhole in lifts commensurate with the soil and compact each backfill lift to the density of the surrounding earth.

Example 1: Bends at points A and B are greater than 45 degrees and are proper. Bends at planned manholes C and D each individually are greater than 45 degrees and are nominally proper, but in combination, they form a virtual angle of less than 45 degrees. Therefore, a manhole is required between points C or D. Measured angles shall take into account entrance and exit angles of the duct if entering or leaving a manhole or hand hole.



(A)

Example 2: A similar example, only with three planned bends between A and E. A manhole must be added at or near point C. Manholes are not necessary at B and D.



(B)

FIGURE 5.5.5.1-1. Adding a manhole at points of tight radius of a duct or conduit.

5.5.5.2 Hand hole installation

The top of the hand hole shall be set above finish grade in unpaved areas to prevent water from ponding on the hand hole. A one eighth inch (1/8") per foot fall from the manhole top to finish grade, ten feet (10') from each edge of the hand hole is recommended.

The hand hole shall be set on a four-inch (4") bed of crushed stone on undisturbed earth. Add a layer of geotextile fabric between the gravel and earth to enhance soil stability and prevent settling of the manhole. The contract drawings will define any additional requirements where soil bearing capacities are an issue/concern.

Backfill around the hand hole in lifts commensurate with the soil and compact each backfill lift to the density of the surrounding earth.

5.5.5.3 Manhole and hand hole penetrations

Where a steel conduit penetrates a wall of a manhole or hand hole, a grounding bushing shall be installed. These grounding bushings shall be connected to each other and to the earth ground system with 6 AWG tinned bare copper conductors.

Conduits entering a junction box or other electrical cabinets from underground shall be sealed with duct sealing compound**.** Expanding foam sealants are not allowed for this purpose.

Conduit connections to exterior boxes, electrical cabinets, or switches shall be made with weatherproof hub fittings.

5.5.6 Mandrel requirements

The contractor shall mandrel each duct or conduit installed and each existing duct or conduit in which cable is installed or replaced. As each conduit run is completed, proceed according to the following steps:

a. For conduit sizes 3 inches (3") and larger, draw a flexible testing mandrel approximately 12 inches (12") long with a diameter less than the inside diameter of the conduit through the conduit. Next, draw a stiff bristle brush through until conduit is clear of particles of earth, sand, and gravel; then immediately install conduit plugs.

b. For conduit sizes less than 3 inches, draw a stiff bristle brush through until conduit is clear of particles of earth, sand, and gravel; then immediately install conduit plugs (see UFGS 33 71 02.00 20).

c. If the mandrel fails to pass through the duct being tested, either the duct is obstructed, misaligned, or the curve has too small a radius. If obstructed, use a high-pressure water jet to clear the conduit. Defective duct(s) shall be exposed and the defect corrected. After the duct(s) are repaired, repeat the mandrel test in that section of duct.

5.5.7 Spare ducts, preparation

Prepare spare ducts in the following manner. Install ¼ inch pull tape having a minimum tensile strength of 400 pounds for non-metallic conduit. The FAA project engineer may specify a larger or more specialized pull tape (impregnated lubricant, distance marking, etc) unless cost prohibitive. Seal the open ends of spare ducts with removable tapered plugs of a type recommended by the duct manufacturers. Adapt the plug to firmly secure the pull tape.

5.5.8 Duct protection

All power cable ducts shall be securely fastened in place during construction and progress of the work, and shall be plugged daily at the end of work to prevent entrance of foreign material. A duct section having a defective joint shall not be installed.

All concrete-encased power cable ducts shall be raised at least 3 inches off the bottom of the trench using spacers (“chairs”). Bottom spacers may be secured to nominal one inch (1”) boards to prevent sinking and overturning. This step shall be followed by a monolithic pour of concrete. Where two or more ducts are encased in concrete the contractor shall space them at not less than one and a half inches (1-1/2”) (measured from outside wall to outside wall) using spacers applicable to the type of duct. As the concrete pour progresses, concrete not less than three inches (3”) thick shall be placed around the sides and top of the duct bank. End bells or couplings shall be installed flush with the concrete encasement where required. Interlock spacers shall be used every five feet (5’) to ensure a uniform spacing between ducts.

Joints in adjacent ducts shall be staggered a minimum of twenty four inches (24”) apart and shall be made completely waterproof prior to covering with concrete.

5.5.8.1 Concrete mix specification

Concrete used in FAA ELD projects shall meet the cement, fine and coarse aggregate, and water specifications; mix design; compressive strength; and curing and protection requirements of FAA Advisory Circular AC-150/5370-10. Concrete for ELD structures such as pads and vaults shall have a minimum 28-day compressive strength of 3,000 psi when tested per ASTM C39. Concrete for concrete-encased ducts shall also meet the minimum strength requirement of 3,000 psi, unless otherwise directed by the FAA Resident Engineer.

5.5.9 Ducts without concrete encasement

Trenches for single-duct power cable runs shall be no less than six inches (6”) or more than twelve inches (12”) wide, and the trench for two or more ducts installed at the same level shall be proportionally wider. Trench bottoms for ducts without concrete encasement shall be made to conform accurately to grade to provide uniform support for the duct along its entire length. A three inch (3”) layer of bedding material shall be placed around the ducts. The bedding material shall contain no particles that would be retained on a half inch (1/2”) sieve. The bedding

material shall be tamped until firm. When two or more ducts are installed in the same trench without concrete encasement, they shall be spaced not less than two inches (2") apart (outside wall to outside wall) in a horizontal direction, or not less than six inches (6") apart (outside wall to outside wall) in a vertical direction.

5.5.10 Separation of cables

For non-distribution power cable installations in the vicinity of power cables, consult first with the FAA office of primary responsibility for guidance.

Subject to the approval of the FAA project engineer, separation of cables installed in conduit or duct shall be as follows:

a. Power cables of the same circuit shall be installed in the same conduit.
b. Conductors of circuits rated 600 volts, nominal, or less, ac circuits, and dc circuits shall be permitted to occupy the same equipment wiring enclosure, cable, or raceway. Conductors shall have an insulation rating equal to at least the maximum circuit voltage applied to a conductor within the enclosure, cable, or raceway. (NEC 300.3 C 1)
c. Conductors of circuits rated over 600 volts, nominal, shall not occupy the same equipment, wiring enclosure, cable, or raceway with conductors of circuits rated 600 volts, nominal, or less unless preauthorized by the FAA project engineer and permitted in NEC 300.3 (C)(2)(a-e).
d. Except in circumstances authorized by the FAA project engineer, power cables shall not be installed in the same duct systems with communication, control, and signal cables.
e. If joint-use applications apply and are authorized, power cable shall be installed in its own separate conduit. This conduit shall be separated a minimum of three inches (3") outside wall to outside wall, from conduits that contain communications, control, and signal cables. The actual separation for each specific case shall be stipulated by the FAA project engineer.
f. Fiber optic, communications, and control cables shall have completely separate and clearly identified and marked hand holes, pull boxes, and junction boxes.

5.5.11 Installation of cables

To minimize splicing, the longest practicable lengths of cable shall be pulled into the ducts at one time. Unless otherwise specified, electrical power manholes and hand holes shall be as far apart as practicable based on the pulling specification of the cable installed. Typically, manholes and hand holes are installed 600 ft apart and at all points where directional change of the duct system is greater than 45 degrees. For long, straight, continuous runs, spacing may be increased, not to exceed 1,200 ft, provided cable manufacturer's specifications for pulling tension has been met, and subject to the project engineer's oversight. To meet grounding requirements of underground multigrounded neutral cable systems over 1000 V, under no condition shall the distance between manholes or hand holes exceed 1,200 ft in accordance with NFPA 70 (NEC) Rule 96C, and ANSI C2 (NESC) standards.

Splicing lengths of cables of different construction types together is not allowed. For example, do not connect shielded cable to concentric cable, or shielded cable to old unshielded cable. Exceptions to this rule will require written PSG approval before installation.

Where a power cable duct or conduit crosses a runway or taxiway, manholes and hand holes shall be placed just outside the RSA/TSA boundaries on opposite sides of the crossing. This will allow for adequate working space to avoid penetrating the safety areas during installation and maintenance activities.

The contractor shall verify that the duct is open, continuous, and clear of debris or blockage (use mandrel) before installing cable. Cable shall be installed in a manner to prevent harmful stretching of the conductor or damage to the outer protective covering or conductor insulation. Until connections are made, cable ends shall be sealed using adhesive-lined, heat-shrink end caps. Where more than one cable is to be installed in one duct, cable shall be pulled at the same time. In no case shall a splice be pulled into a duct or conduit.

When cable cutting is required, cable ends shall be effectively sealed against moisture immediately after cutting, using end caps as above. Bends of a radius less than eight (8) times the diameter for rubber-covered or plastic-covered cable, or twelve (12) times the diameter for metallic armored cable, shall not be made. Cable that has been kinked shall not be installed.

When unreeling, an observer shall be stationed at the reel to report cable irregularities. Unless specifically stated in the drawings, cables for installation in ducts or for direct burial shall comply with FAA-E-2013D and FAA-E-2793A. Specifically excluded are bare concentric neutral wire cable types. Grounding conductors, where required, shall be a minimum size of 6 AWG bare copper wire. Fire wrap medium voltage cables in all manholes and hand holes.

5.5.12 Cable pulling

The below provisions on cable pulling shall be followed unless otherwise specified on the submittals matrix (Appendix E).

The contractor shall obtain from the manufacturer an installation manual or set of instructions that address such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure.

The contractor shall then perform pulling calculations and prepare a pulling plan, which shall be submitted along with the manufacturer’s instructions. Cable shall be installed strictly in accordance with the cable manufacturer's recommendations, ANSI/IEEE C2 standards, and the authorized installation plan.

The pulling plan shall include:

a. Site layout drawing(s) with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull.

b. List of cable installation equipment.

c. Lubricant manufacturer's application instructions. Corrosive lubricant is prohibited.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls (calculated values, not maximum values).

f. Cable percentage conduit fill.

g. Cable sidewall bearing pressure.

h. Cable minimum bend radius and minimum diameter of pulling wheels used.

i. Cable jam ratio. Refer to Appendix B, item 4).

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device (see UFGS-33 71 02.00 20).

Prior to pulling cable, pump the water out of the manholes and pull a mandrel/swab 1/4 inch smaller than the duct diameter through duct run to ensure adequate opening of duct run. Thoroughly swab conduits to remove foreign material before pulling cables.

Cables shall not be pulled from an outdoor (exterior) location when the outdoor (exterior) air temperature is below the cable manufacturer’s minimum recommended pulling temperature.

Contractor shall furnish required installation tools to facilitate cable pulling without damage to the cable jacket. Such equipment is to include, but be not limited to, framework, sheaves, winches, cable reels and/or cable reel jacks, duct entrance funnels, pulling tension gauge, and similar devices.

The diameter of the sheaves shall be at least 10 times that of the diameter of the largest cable. Equipment shall be of substantial construction to allow steady progress once pulling has begun. Makeshift devices which may move or wear in a manner to pose a hazard to the cable shall not be used. Cable installation may be accomplished using a power winch or by hand.

Cable pulling lubricant shall be used to ease pulling tensions. The lubricant shall be compatible with the jacket material. The FAA project engineer will authorize the pulling compound. Lubricant shall be water or silicone based so as not to injure the cable material used. Wax-based

lubricants are not allowed. Lubricant shall not harden or become adhesive with age. Petroleum grease shall not be used.

Cable ends shall be sealed and firmly held in the pulling device during the pulling operation.

Use of a tensiometer is required for cable-pulling operations. Actual pulling tensions shall be continuously monitored and compared to both (1) calculated pulling tensions as in item “e” above, and (2) maximum allowable pulling tensions as in item “j” above. If actual pulling tension exceeds calculated pulling tension by 30% or more, the pulling operation shall be suspended and the project engineer consulted for investigation of a possible pulling obstruction or other anomaly. The cable pulling operation shall not exceed maximum allowable pulling tension. See Figure 5.5.12-1.

During pulling operations, several personnel shall be stationed at key points to ensure safety to cable and personnel: at duct entry, duct exit, cable feed, and at the pulling machinery.

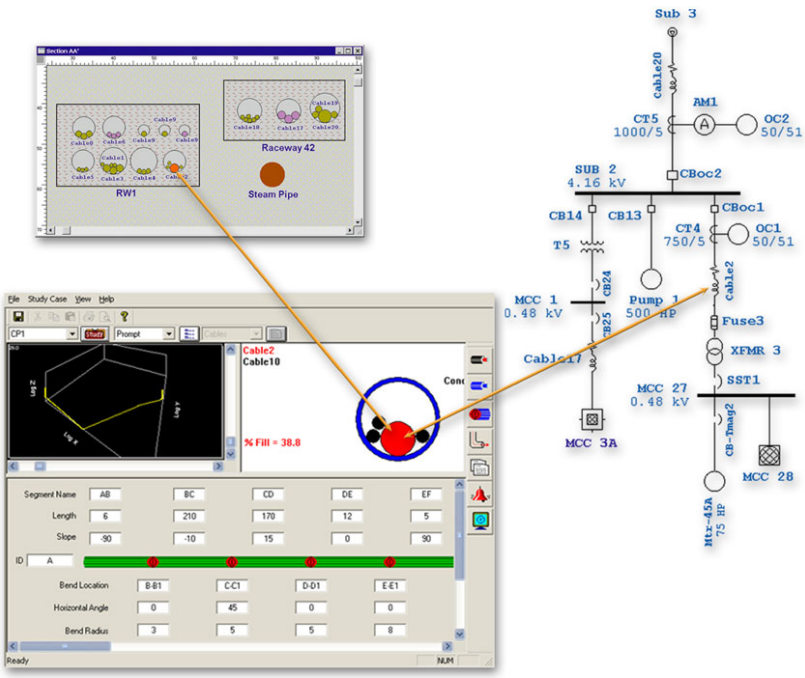


Diagram courtesy of ETAP Cable Systems Software

FIGURE 5.5.12-1. Industry software is readily available to assist with pulling calculations.

Avoid abrasion and other damage to cables during installation. The surface of a cable sheath or jacket shall not be damaged to a depth greater than one tenth ($1/10^{th}$) the original thickness or be flattened out-of- round more than one tenth ($1/10^{th}$) of the outside diameter.

Where cables are left in manhole or switchgear overnight or more than 8 hours prior to termination, the cable ends shall be sealed with paraffin or shrink wrap caps and supported in a

manner which will prevent entrance of moisture into the cable. Cable shall be terminated and energized as soon as possible.

Table IV lists example maximum pulling tensions for commonly installed cables (see also Appendix B for a pocket guide on calculation method).

The table is for illustration purposes only; it is the designer's and/or installer's responsibility to obtain the manufacturer’s data for the cable chosen for installation. The manufacturer’s data shall be used in conjunction with the pull-configuration(s) proposed, cable type and ampacity, size of conduit, distance, grade, degree of sweeps/bends, proper lubricant, etc, to calculate the maximum tension for each cable pull. The resulting value shall not exceed cable maximum tension and maximum sidewall pressure values.

5.6 Medium-voltage direct earth buried cables

Direct earth buried (DEB) cables are to be avoided. However, if preauthorized per the FAA-approved drawing set and construction specifications, DEB cable construction shall meet the following requirements. Coordinate underground power cable installation work to avoid interference with other airport projects and with existing utilities.

General--The contractor shall excavate trenches for direct-earth burial cable as follows:

a. To the depth specified in paragraph 5.4.1b.

b. To a width of not less than four inches (4”) for single or six to eight inches (6-8”) for multiple runs of power cable.

c. To a width and depth that will provide horizontal or vertical separation of power cables from other power cables of different voltage ratings, or from power cable and a control or signal cable.

d. Where soil is known to be rocky, select backfill for cable protection. Backfill shall be firmly tamped in the separation area.

e. Restoration shall be in accordance with paragraph 5.5.3.

Unless otherwise specified, power cables in the same location and routed in the same general direction shall be installed in the same trench. Trenches for cables may be excavated manually or with powered trenching equipment. Cable plows shall not be used unless express permission is granted by the FAA project engineer. When rock is encountered, remove to a depth of at least 3 inches (3”) below the cable and fill the space with sand or clean earth free from particles larger than 1/4 inch. Bottoms of trenches shall be smooth and free of stones and sharp objects. Where materials in bottoms of trenches are other than sand, a 3-inch layer of sand shall be laid first and

TABLE IV. Maximum allowable non-armored cable pull tensions using dynamometer or rope.

CABLE	TENSION (Pounds)	ROPE DIAMETER (INCHES) Cotton	Manila	Dacron	Nylon
2 - 1c #8 Solid	264	3/16			
3 - 1c #8 Solid	264	1/4	3/16		
4 - 1c #8 Solid	422		1/4		
2 - 1c #6 Stranded	420	1/4	3/16		
3 - 1c #6 Stranded	420	5/16	1/4		
4 - 1c #6 Stranded	672	3/8		3/16	
1 - 2c #8 Stranded	264	1/4			
1 - 3c #8 Stranded	396	1/4			
1 - 4c #8 Stranded	528		1/4		
1 - 2c #6 Stranded	420	1/4	3/16		
1 - 3c #6 Stranded	630	5/16			
1 - 4c #6 Stranded	840	3/8	5/16	3/16	
1 – 1c #4 Stranded, Conc Neut (CN)	334	For pull rope sizes, consult manufacturer (etc)			
2 – 1c #4 Stranded, CN	668				
3 – 1c #4 Stranded, CN	1,002				
4 – 1c #4 Stranded, CN	1,069				
3 – 1c #2 Stranded	1,593				
4 – 1c #2 Stranded	1,699				
3 – 1c #2 Stranded, CN	1,856				
4 – 1c #2 Stranded, CN	1,962				
3 – 1c #1/0 Stranded	2,534				
4 – 1c #1/0 Stranded	2,703				
3 – 1c #1/0 Stranded, 600 V	2,955				
4 – 1c #1/0 Stranded, 600 V	3,124				

Legend: No. of cables - No. of conductors (c)/ Gauge (AWG)
Note: The above figures are to be used as a guide only. Consult with the manufacturer for exact maximum pull tensions for a given cable type. Ensure conformance with the ANSI/IEEE C2 standards.

compacted to approximate densities of surrounding firm soil. Trenches shall be in straight lines between cable markers. Bends in trenches shall have a radius of not less than 36 inches (36”) consistent with the cable manufacturer's published minimum cable bending radius for the cable installed. Walls of trenches shall be essentially vertical so that a minimum of shoulder surface is disturbed.

Trenches shall be opened only for the time required to install, inspect and survey the cables in accordance with FAA Advisory Circular 150/5370. The trench shall be closed in the same working day or marked, barricaded and/or lighted according to current airport specifications and requirements.

Installation in trench--Direct earth burial cable shall be unreeled in place along the sides of or in trenches and carefully placed on sand or earth bottoms. Pulling cables into direct-burial trenches from a fixed reel position shall not be permitted, except as required to pull cables through conduits under paving or railroad tracks. Dragging cables over the ground shall not be permitted.

Separation of cables--Separation between direct earth burial cables shall be as follows:

a. Power cables may be laid together in the trench. In these instances, there shall be a minimum of 3 inches (3”) of separation between cables.

b. Non-power cables (fiber optic, communications, and control cables) shall be installed in a separate trench from power cables (exception: DEB power cable crossing a control cable at the perpendicular and with 12 inches [12”] vertical separation). A concrete marker indicating the presence of power cables shall be installed along the route of the trench.

c. Where cables of different types (power and control or signal) or of different voltages are installed together as stated in (a) and (b) above, the individual cables or groups of the same type cables shall be clearly and unambiguously identified by installing metal or approved plastic tags indicating the type (power, control or signal) and voltages for power cables. These tags should be installed in accordance with Section 5.11.

d. Backfill that serves to separate cables shall be firmly tamped.

Bends--Bends in cables shall have an inner radius not less than those specified in NFPA 70 for the type of cable, or manufacturer's recommendation.

Splicing--Where splices are required, provide splices designed and rated for direct burial. See splicing Section 5.9 for instructions. All splices shall have their neutrals/shield solidly grounded.

Slack loop--A slack loop shall be provided at each end termination point of a cable to facilitate any future repairs. Slack loops shall have no bends with an inner radius less than twelve times the outside diameter of the cable. Where cable is brought above ground, additional slack shall be as shown by the drawings or as directed by the FAA.

Backfilling--After underground medium-voltage DEB cable has been installed and inspected, the trench shall be backfilled. The first layer of backfill shall be 3 inches (3") deep, loose measurement, and shall be either earth or natural sand containing no material aggregate particles that would be retained on a one quarter inch (1/4") sieve. This layer shall not be compacted. The second layer shall be 9 inches (9") deep, loose measurement, and shall contain no particles that would remain on a one inch (1") sieve.

The remainder of the backfill shall be excavated or imported material (if necessary) and shall not contain stone aggregate larger than 4 inches (4") maximum diameter. The second and subsequent layers shall be thoroughly tamped and compacted to the density of the adjacent undisturbed soil.

Thermal resistivity--Trench backfill shall have a soil thermal rho of 90°C-cm/W or less.

Screening/sieving-- Compacted trench backfills shall meet ASTM D422 and ASTM D698, shall be sufficiently compacted, and shall not have backfill lifts that are too thick. Failure to prepare backfill properly will result in degraded thermal capability of the cable system.

5.7 Cable installation in manholes

Cables shall be carefully formed on nonmetallic racks around the interior of manholes or hand holes, avoiding sharp bends or kinks. Ensure that enough cable is coiled in the manhole so that a number of splice repairs can be made without having to fully enter the manhole. Tie splices and cables to cable racks using one eighth inch (1/8") nylon line. Splices shall be a minimum of two feet (2') from the mouth of the duct opening into the manhole or hand hole. Where this is not possible, splices shall be located as advised in the manhole/hand hole specification or drawing. Splices in different cables shall be staggered.

5.8 Cable terminations, connections, surge protection, and fault protection

5.8.1 Cable terminations and connections

Installation of prefabricated cable terminations shall strictly conform to manufacturer's installation recommendations using proper specialized tools. A cable manufacturer's representative shall be present at least in the initial phase to provide guidance to the installation team. Special care shall be exercised to use the proper ratings and physical dimensions.

5.8.2 Connections to a three-phase engine generator

When providing backup power to other facilities, connect the two new single-phase legs to the lowest loaded phases of the generator. The lowest loaded phases shall be determined by performing a load reading. This reading shall be confirmed by referring to the history of the technical performance record (TPR).

5.8.3 Surge protection

Apply surge protection in accordance with the following standards:

a. For FAA-owned low voltage power systems (600 V or less) at or after the facility service entrance, surge protection devices (SPD) shall be applied in accordance with FAA-STD-019.

b. In ELD installations, a fused disconnect switch may be installed before the TVSS and connected to the line side of the service. The TVSS must be a UL 1449 (third edition) Type 1 device, which allows for protected line-side connection.

c. Surge protection for the 1000 V to 15 kV medium voltage range shall be implemented in accordance with ANSI/IEEE C62.11 and NEC Article 280.

d. Limit nominal voltage of ELD systems to 34.5 kV. For any other voltages, consult with the office of primary responsibility.

The following guidelines apply to locating and installing surge protection devices (SPD) (see Appendix A for product operating parameters).

a. If an FAA-owned distribution transformer is fed from an overhead line by means of a medium voltage cable, surge arresters of the metal-oxide varistor (MOV) type shall be installed at the pole top and at the transformer between each phase and ground. The pole type arrester shall be of the intermediate class, while the transformer surge arrester shall be of the distribution type. The continuous voltage rating of the arresters shall be determined in a protection and insulation coordination study. As a further protection against direct lightning, intermediate arresters shall be installed one span before and after the interconnection of transformer. Surge arrester leads connecting to cable conductor and grounded metal shield must be as short as possible to minimize the protective voltage level. This recommended surge protection scheme is illustrated in Figure 5.8.3-1.

b. If an FAA-owned distribution transformer is fed from a station transformer directly by means of a medium voltage underground cable, a distribution arrester shall be installed at both ends of the cable in accordance to the guidelines provided in paragraph (a) above.

c. Install surge arrestors of the proper class on transformers.

d. Unless otherwise shown on the drawings, surge arresters are not required on medium-voltage switchgear and sectionalizers.

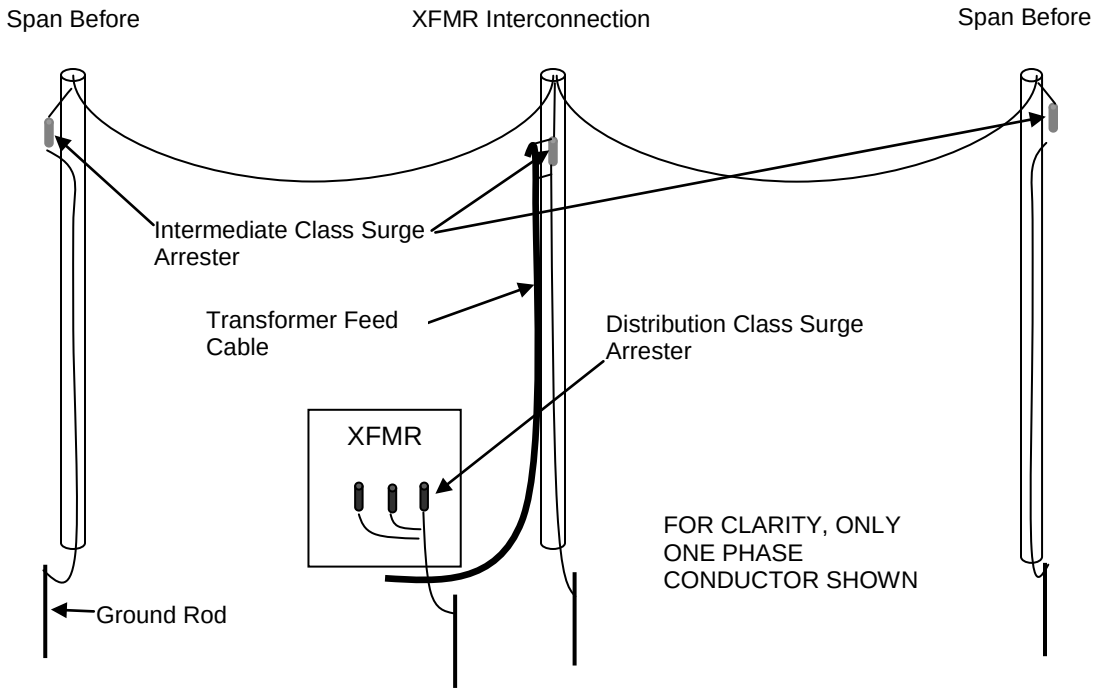


FIGURE 5.8.3-1. Schematic representation of recommended surge protection system.

5.8.4 Fault isolation

Use sectionalizers to protect the underground electrical line distribution circuit as a whole from electrical faults. This shall be accomplished by isolating faults to single National Airspace System (NAS) facilities versus multiple facilities ("daisy chained"). Where existing power cable layouts do not permit the isolation of individual facilities, add a sectionalizer.

Similarly, do not connect transformer primaries in a given electrical line distribution (ELD) service together in parallel such that a single power cable or transformer fault upstream will be allowed to deenergize downstream loads in the ELD circuit, thereby disabling multiple NAS facilities.

5.9 Splices

Whenever possible and while still meeting required cable grounding standards, splices are to be avoided. Splices on multiple cables in a trench shall be staggered. Cable ends to be spliced shall be kept free from moisture by using tape or caps. Cable runs shall be given continuity and insulation resistance tests per this specification at the completion of each splice. When conducting FAA-authorized third-party testing, at the completion of the installation of each cable section (from termination to termination), subject the cable section to a 50/60 Hz partial discharge test in accordance with IEEE 400.3 at up to 2.5 times operating voltage level for a duration not to exceed 30 seconds, while the cable section is disconnected from the rest of the

system. Any partial discharge within a splice shall comply with the requirements of IEEE 404. Splices are not to be drawn inside of any conduit or duct.

Buried and nonseparable T and Y joints shall not be used. These joints are inherently unreliable and cannot be properly commissioned with partial discharge diagnostics. Finding a fault becomes more difficult and harmful to existing cable assets. In addition, faults due to these types of unreliable joints can cause failures in multiple facilities due to a lack of sectionalizing.

Each cable splicer shall be qualified in making cable splices and in the use of specified cable splicing kits and specialized tools. The contractor shall obtain FAA authorization of the splice and cable splicer prior to making field splices. Cable splicing methods and materials shall be of a type recommended by the splicing materials manufacturer for the cable to be spliced, and a cable manufacturer's representative shall be present at least in the initial phase to provide guidance to the installation team. Splices shall be as follows.

a. Medium voltage power cables (600 volts and above). Use cold-shrink splice kits. The contractor shall make sure that the proper kit and tools are used for each application. The cold shrink product shall meet ANSI/IEEE Std. 404 (for a 15 kV rating).

b. Power cables 600 volts and below. Use heavy-wall self-sealing heat-shrinkable tubing meeting ANSI-C119.1-2006, poured epoxy splice, or any other splicing means approved by ANSI standards.

c. Cable armor and shields. Armor and shield may be folded back prior to splicing, then reinstalled across the splice and bonded by the use of authorized bonding clips, or soldering when copper material is used. If the armor is galvanized material, it shall be bolted. Excess threads should be cut from bolts and wrapped with butyl tape so there are no sharp projections prior to using heat-shrink tubing.

d. Evaluation of products. As a submittal to FAA, the contractor shall provide the product drawings showing details of the splicing methods to be used, and a statement documenting the 3-year experience qualification of the contractor in making splices on underground systems with the proposed product (reference FAA Advisory Circular 150/5370-10). In addition, products shall meet the latest editions of standards in Table V.

TABLE V. Cable splicing specification equivalents.

APPLICATION STANDARD	LEVEL OF ACCEPTANCE
IEEE-404 Standard for Power Cable Joints	Meet or Exceed
IEEE-48 Standard for Cable Terminations	Meet or Exceed
ANSI C119.1 Sealed Insulated Underground Connector System Rated 600 Volts	Meet or Exceed
IEEE – 386 Standard for Separable Insulated Connectors	Meet or Exceed

5.10 Equipment racks and disconnect switches

Equipment racks - If vertical supports for equipment racks supporting disconnect switches are separated by more than 6 feet, add a middle (third) vertical support.

Main disconnect switches – Ensure that installed MDSs meet NEMA 3R for typical applications, NEMA 4X for corrosive environments. If required by the designer, use bollards to protect the installation from vehicle impacts. Construct pads of concrete, or use prefabricated composite pads.

Lightning protection of equipment racks – Air terminals shall be installed on each end of an equipment rack, regardless of rack width or proximity to a zone of protection of other nearby facilities. Air terminal selection and grounding shall conform to FAA-STD-019.

5.11 Grounding of ELD systems

Local published standards may take precedence over the national standard. In the case of ambiguity or significant deviation, contact Power Services Group, Power Cable Program Office, to provide a technical evaluation. ELD system grounding shall comply with FAA-STD-019, NFPA 70, IEEE C2, and in accordance with the specific guidance provided herein.

Typical FAA medium-voltage ELD elements to be grounded include:

a. Power Cables – ground the multigrounded neutral wires and shields,
b. Guard wires,
c. Manholes and hand holes,
d. Equipment and equipment enclosures,
e. Surge arresters,
f. Steel conduits and fittings based on application,
g. Direct earth buried power cables – multigrounded shields,
h. Abandoned power cables--ground the conductor(s) and the multigrounded neutral wires and shields (if present).

Typical FAA low-voltage ELD elements to be grounded include:

a. Low-voltage cable segment between a facility transformer and the service entrance,
b. Service entrance disconnects, meter bases, and associated equipment,
c. Service entrance equipment racks.

5.11.1 Power cables, multigrounded neutral wires and shields

The FAA ELD systems follow the same practice as multigrounded (solidly grounded, reactance grounded) medium voltage neutral systems in common use by the electric utility companies.

FAA power cables (both in conduit and DEB) shall be effectively grounded by ground connections of sufficiently low impedance levels (< 7 ohms), and have sufficient current carrying capacity to limit the buildup of voltages to levels below those that may result in undue hazards to persons or connected equipment.

Multigrounded system—FAA medium voltage cables typically use metallic shields that require grounding (NEC requirement above 5 kV). The shields confine electric fields within the cable to obtain uniform radial distribution of the electric field, protect against induced voltages, and reduce the shock hazard risk to personnel. To effectively ground the shield, install multiple grounds to the cable neutral conductor to limit the voltage rise to 25 volts maximum (measured from neutral to earth ground) per IEEE Std 525. This shall be accomplished by connecting the neutral of the multigrounded system to electrodes at each transformer location and at a sufficient number of additional points totaling not less than four ground points in each mile of the entire line (every 1300 ft / 400 m [¼ mile], or less), not including grounds at individual services. This rule applies to underground jacketed shielded cable and to jacketed concentric neutral cable. (Ref NESC Section 9, Rule 096, *Ground Resistance Requirements – Multigrounded System)*. The same practice applies to different kinds of cables; for example, concentric wire, tape shield, etc.

Bonding across joints--Apply a shield bonding jumper wire across cable splices.

DEB cable shield and separate neutral conductor grounding – Ground direct earth buried cable shields and shields of separate neutral conductor cables at least eight times per mile (not to exceed 660 ft spacing), not including grounds at individual services, in accordance with NESC C2, Rule 354.D.3c).

Service Laterals--For service laterals, when two disconnects are separated by 200 feet or more, neutral-to-ground bonds are required at both locations in accordance with the national electrical safety code (NESC). When the distance is less than 200 feet, the disconnect closest to the transformer shall have the neutral to ground bonded. Typically, this is the first disconnecting means in accordance with the National Electrical Code (NEC).

5.11.2 Cable guard wires

Guard wires protect the power cable from lightning surges. The contractor shall install cable guard wires for all buried cables and conductors not routed in ferrous conduit to protect underground conductors from the effects of lightning discharges. A 1/0 AWG bare copper stranded guard wire shall be used. The guard wire shall be embedded in the soil a minimum of 10 inches (25 cm) directly above, centered and parallel to the cable and/or duct to be protected.

When the width of the cable run or duct does not exceed 3 ft (90 cm), one guard wire centered over the cable run or duct shall be installed. When the cable run or duct is more than 3 feet (90 cm) in width, two guard wires shall be installed. The guard wires shall be spaced at least 12 inches (30 cm) apart and not be less than 12 inches (30 cm) or more than 18 inches (45 cm) inside the outermost wires or the edges of the duct.

The guard wire shall run continuously along the cable/duct run with no deviations from the run of the duct, and with no gaps. The guard wire shall be bonded to the earth electrode system (EES) at each end and to ground rods at approximately 90-foot intervals using exothermic welds. The spacing between ground rods shall vary by 10% to 20% to prevent resonance. Install the ground rods approximately 6 feet (2 m) on either side of the trench and connect them via jumper wire to the continuously running guard wire as shown in Figure 5.11.2-1. The jumper wires shall be swept away from the guard wire in a repeatable pattern such that a lightning impulse will always be able to follow a curved path to ground within 180 ft. of any point along the run. Maintain a minimum 9-in. radius bend in the jumper sweeps.

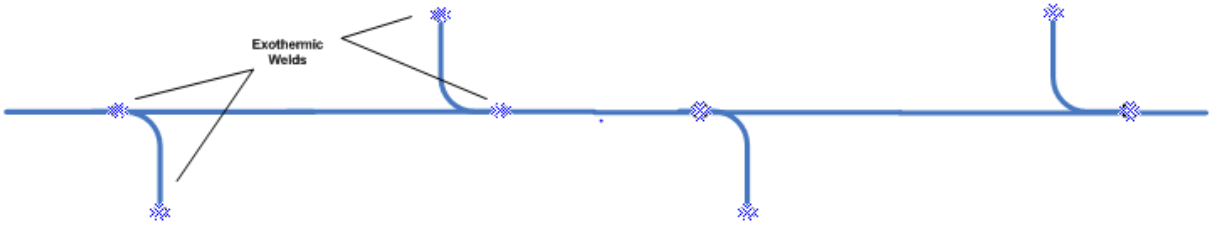


Figure 5.11.2-1 Grounding of cable guard wire. Note the alternating direction of the sweeps of the jumper wires. This pattern is required for the proper protection of the power cable.

For difficult excavations, such as rock formations or permafrost, the ground rods may be driven 3 feet on either side of the trench.

5.11.3 Manholes and hand holes

Power and control cables shall be installed in separate manholes and hand holes.

Until ready for acceptance testing, no installation work shall involve energized systems. Install power cables, ground wires, grounding loops, and manhole racks and furniture in such a way as to give maximum safe clearance space for personnel to enter the manhole when conducting subsequent operation and maintenance tasks. Conductors shall be placed well out of the way of human ingress/egress pathways through the manhole or vault. During acceptance inspection, manhole installation configurations that are found to be untidy and/or lacking in clearance for later maintenance tasks shall be required to be redone at the contractor’s expense.

If space is available, cable slack sufficient for one splice for each cable shall be left in each manhole. Elimination or shortening of slack lengths shall require authorization by the FAA.

All new and existing cable in manholes shall be secured to nonmetallic racks on the manhole walls. Cables shall be secured to racks or mounted on a heavy duty nonmetallic multi-mount cable support arm.

Jumper cables shall be routed in such a manner that through-air clearance between adjacent conductors, and between conductors and any metallic or grounded surface, is maintained.

Physical dimensions of manholes may be altered to fit requirements. The following procedure covers the minimum grounding requirements (Figure II):

a. Install a solid, bare copper bus bar inside the manhole, or alternatively, run a 4/0 bare copper conductor along the inside of the manhole, creating a grounding surface about 12 inches (12”) above the finished floor. Arrange bus bar or conductor so as to avoid interference with duct entrances into the manhole, and construct of sufficient length to facilitate repair and future installation operations.
b. Bond all cable shields (or steel interlocked armor if used) to the bus bar in accordance with the manufacturer’s directions. Bond other metallic bodies to the bus bar with a minimum 6 AWG bare copper conductor using mechanical connections and two-hole lugs.
c. Connect and exothermically weld the 1/0 AWG guard wires to the outside ground rods on each side of the manhole, ensuring 10 feet (10’) distance from the outside of the manhole to the ground rod.
d. If feasible, all connections, sweeps, or curves in the grounding system shall be smooth and shall be of at least 8 inch (8”) radius no matter what the orientation (vertical or horizontal).
e. All splices inside a manhole shall be solidly grounded, with jumpers running across the joints to connect the cable shields.
f. Mechanically connect and bond the manhole frame to the bus bar using two-hole lugs and a 6 AWG solid copper ground conductor.
g. Apply expandable foam duct sealant at openings to prevent water and gas from entering manholes.
h. Hand holes follow the same basic principles as above, with appropriate modifications.

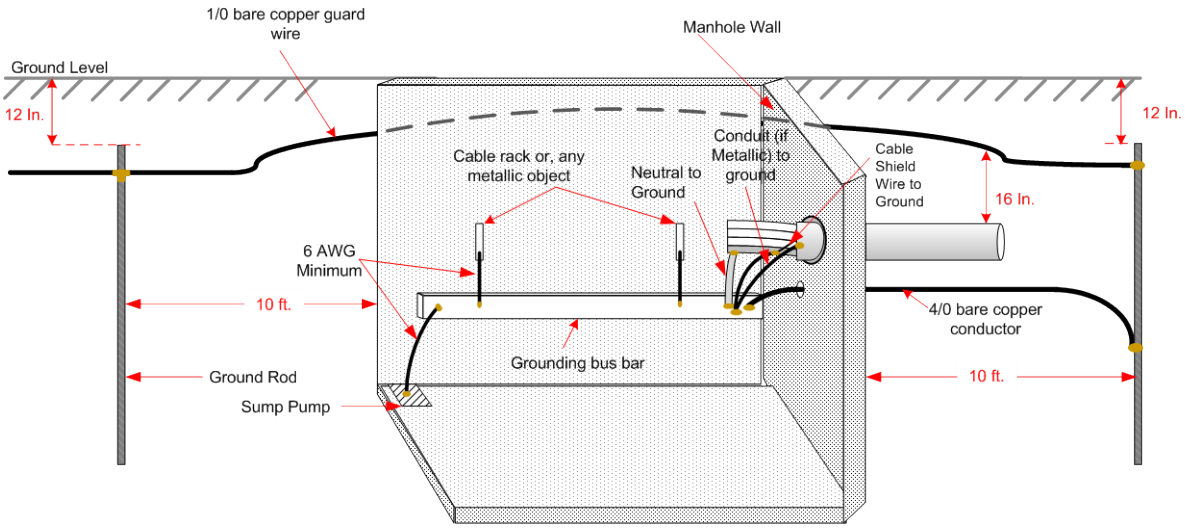


FIGURE 5.11.3-1. Grounding and guard wire installation detail at a manhole.

Where multiple conduits enter manholes, the following schemes illustrate guard wire grounding methods (all sharp corners to be rounded out) (Figure III).

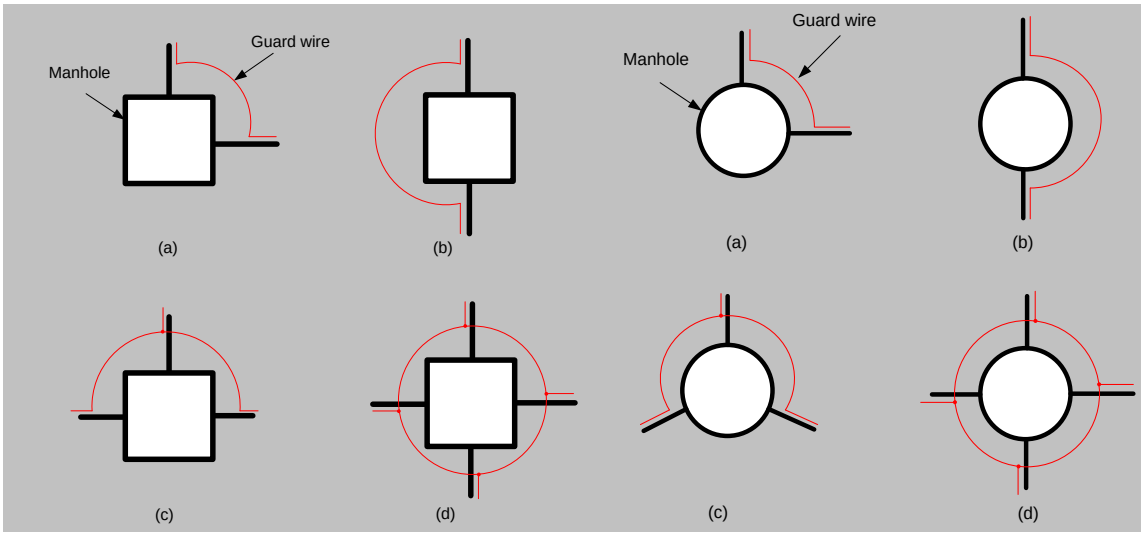


Figure 5.11.3-2. Guard wire grounding schemes.

5.11.4 Equipment and equipment enclosures

Where feasible, ground ELD equipment and equipment enclosures in accordance with NESC ANSI C2 Section 38, Rule 384 (for medium voltage equipment), FAA-STD-019 (for low voltage equipment), and IEEE 80 (when bonding grounding conductors to FAA NAS earth electrode systems).

For FAA ELD systems, ground rods shall be interconnected by a buried, bare, 4/0 AWG copper conductor (ground loop or counterpoise). Connections to the ground rods shall be exothermically welded. The interconnecting conductor shall close on itself forming a complete loop (“ground ring” or “counterpoise”) with the ends exothermically welded.

Pad-mounted transformers and other pad-mounted equipment—At a minimum, install a single ground rod. Bond the transformer equipment frame and other non-current-carrying metal parts, such as cable shields, cable sheaths and armor, metallic conduit, and other non-current-carrying metal parts to the equipment counterpoise using exothermic welds. Ground the secondary neutral.

Equipment racks—Install a counterpoise 2’ to 6’ from equipment racks. Counterpoise shall consist of bare 4/0 copper conductors and driven ground rods around the rack. Ground the equipment rack and equipment and other non-current-carrying metal parts to the counterpoise using exothermic welds. If equipment rack is within 15 feet of a shelter having an existing FAA NAS EES, a connection between both counterpoises shall be made.

Connect metallic conduits that terminate without mechanical connection to the enclosure by grounding bushings and grounding conductor to the equipment ground bus.

Route cables within switchgear and enclosures in a manner which will allow room for bending and terminating of cables. Cables shall be secured in a manner that will not result in cable weight being placed on the termination electrical joint. Cable support shall be made in a manner that does not force cable against grounded metal or that compresses cable diameter. Cable training bend radius shall be at least 12 times cable diameter or shall not be installed.

Route jumper cables in a manner that maintains through-air clearance between adjacent conductors and between conductors and any metallic or grounded surface.

5.11.5 Surge arresters

Follow detail drawings in the drawing set for surge arrester grounding. For ungrounded and single-grounded systems, modify the requirement in accordance with IEEE C2 and UFC 3-550-03FA.

Bond surge arresters and neutrals directly to a transformer enclosure and then to the grounding electrode system using a bare copper conductor. Keep lead lengths as short as possible with no kinks or sharp bends.

5.11.6 Conduit and fittings

Conduit joints and fittings shall be electrically continuous between joined parts. Ferrous conduit enclosing power conductors to FAA facilities shall be terminated using conductive fittings to their respective junction boxes, equipment cabinets, enclosures, or other grounded metal structures.

5.11.7 Low-voltage cable runs to facility service entrances

The ELD low-voltage (≤ 600 V) cable runs coming from a commercial utility power meter and feeding power to FAA facility service entrances are considered to be FAA owned and operated utility distribution systems and shall follow the grounding and safety requirements of IEEE C2/NESC. Wiring after the distribution service delivery point (usually at the terminals of the service equipment but always as close to the FAA facility as possible) is generally considered premises wiring and shall follow NEC/NFPA 70 Section 250, *Alternating Current Systems between 50 V and 1000 V.*

For the grounding requirements of service laterals, consult the grounding section of this specification.

There are gray areas in determining which electrical safety and grounding codes apply (NESC or NEC); consult the office of primary interest to determine whether a segment is distribution or premises wiring.

5.11.8 Installation details

5.11.8.1 Installation of equipment counterpoise and ground rods

To meet site grounding requirements, install equipment counterpoise and ground rods according to the design drawings to ensure that the desired grounding values are achieved at all points of the ELD system.

Equipment counterpoise (pad mount loop) – Where not on or within 15 feet of an FAA NAS earth electrode system (EES), install bare 4/0 AWG copper conductors in a loop not less than 12 inches (12”) below finished top of soil grade, or consistent with IEEE 80. Connect the counterpoise to ground rods using 4/0 AWG copper conductors and exothermic bonds.

When installing the pad mount loop on or within 15 feet of a NAS EES, a deeper burial depth may be required. Consult FAA-STD-019 or the project drawings.

Ground rods - Drive cone-pointed ground rods to full depth plus another 12 inches below grade. Ensure that the installation provides an earth ground of the appropriate value for the particular equipment being grounded. Neatly and firmly attach and exothermically weld ground rods to the counterpoise and keep the amount of exposed bare wire to a minimum.

5.11.8.2 Grounding and bonding connections at or within equipment enclosures

When feasible, where grounding connections are buried, external to equipment enclosures, or otherwise normally inaccessible and/or uninspectable, use exothermic welds. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds that are "puffed up" or that show convex surfaces indicating improper cleaning are not acceptable. No mechanical connectors shall be made below grade.

Mechanical connections within equipment enclosures above grade shall employ bolted solderless connectors, in compliance with UL 467.

5.11.8.3 Routing grounding and bonding conductors

Connect and bond transformer enclosures and equipment frames to the grounding counterpoise system. Size grounding and bonding conductors in accordance with the drawings. Bends less than 90 degrees are not permitted. Avoid routing ground conductors through concrete. When concrete penetration is necessary, cast nonmetallic conduit flush with the points of concrete entrance and exit so as to provide an opening for the ground conductor. Seal the opening with a sealing compound after installation.

5.11.8.4 Grounding cable across expansion joints

For grounding cables that cross expansion joints or similar separations in structures and pavements, use approved devices or methods of installation to provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

5.11.8.5 Grounding of armored cable and metallic conduit

Apply the following requirement during initial cable installation. For medium voltage systems, bond cable armor and/or metallic conduit to the earth electrode grounding systems of the connected equipment at both ends with a 2 AWG conductor, including at splices in manholes and hand holes. An armored bonding jumper shall be installed across each splice. For low voltage systems, bond the cable armor to the ground bus of the service disconnecting means at the electrical service entry point. Bonds shall be electrically continuous between joined parts (see FAA-STD-019).

5.11.8.6 Grounding metal splice cases

Ground metal splice cases for medium-voltage direct-burial cable by connection to a driven ground rod located within 2 feet of each splice box using a grounding electrode conductor having a current-carrying capacity of at least 20 percent of the individual phase conductors in the associated splice box, but not less than No. 6 AWG.

5.11.8.7 Grounding Riser poles

Directly connect equipment, neutrals, surge arresters, and items required to be grounded to the single continuous vertical ground rod conductor (No. 2 AWG minimum) on each riser pole. Ensure that ground rod conductors are stapled to wood poles at intervals not exceeding 2 feet.

5.12 Cable tagging, equipment markers and labels, and safety signs

5.12.1 Cable tags

Individual cables or groups of the same type of cable shall be clearly and unambiguously identified in accessible locations such as manholes, hand holes, junction boxes, and pull boxes by means of a minimum of two tags per cable, one near each duct entrance hole. Unless otherwise specified in the contract documents, cable tags shall be constructed of metal, or of rigid laminated plastic of at least 1/16” total thickness.

Plastic tags shall be exterior classified and consist of two plies: a plastic base and a 0.005” surface of impact acrylic plastic for front engraving. The tag shall be ultraviolet (UV) light stable. Engraving shall be done with 1/4-inch minimum lettering (white background and black letters). Tags shall be attached to the both terminated ends of the cable with two UV-rated nylon or stainless steel cable ties.

Cable terminations and potheads shall be tagged as to function, including facility which they serve, and any pertinent data. Tags shall be marked with an abbreviation of the name of the facility or facilities served by the cable plus the letter “P” (Power). Where more than one identical cable is used to serve the same facility, cables may be bundled under one tag unless job plans state otherwise.

5.12.2 Equipment markers and labels

Design and select equipment markers and labels for exterior use.

5.12.2.1 Exterior equipment identification tags, labels, and plaques

Aluminum tags, or any other tags or labels approved by the project engineer, shall be printed with numbers to identify ELD equipment. Attachment options include wires and ties, or screw mounts, nails, or bolts. Contrasting colors shall be considered when ordering tags and labels. Plaques may be made of laminated plastic.

5.12.2.2 Warning and safety signs and labels

To minimize accidents, manufacturers of electrical products use ANSI Z535, *Safety Alerting Standards*, to make their products and manuals safer. Contractors shall ensure that colors, safety signs and labels, safety symbols, barricade tapes, and information on product manuals, instructions, and collateral materials applying to FAA ELD equipment meet ANSI Z535.1 thru .6 standards.

5.12.2.3 Arc flash hazard labeling

In instances where an arc flash analysis has been completed and updated with any as-built changes, the results of the study shall be labeled on all corresponding equipment, as well as the drawings. Follow NEC Article 110.16 for guidance on warning labels.

Electrical equipment shall be field marked to warn qualified persons of potential electric arc flash hazards. The marking shall be located so as to be clearly visible to qualified persons before installation of the equipment.

Following the completion of arc flash hazard and shock analyses, the electrical equipment evaluated shall be labeled to include the findings of the analyses. At a minimum, the label shall include the following information: flash hazard boundary; incident energy (calories/cm^2) at appropriate working distances; personal protective equipment (PPE) level - including what fire-retardant clothing is required; shock hazard level (kV); limited approach boundary (feet/inches); restricted approach boundary (feet/inches); class of voltage-rated gloves for restricted approach boundary; prohibited approach boundary (feet/inches); class of voltage-rated gloves for prohibited approach boundary; equipment name; additional PPE required (ear, eye, face, and/or head protection); and date of survey.

5.13 Cable markers

5.13.1 Concrete markers for DEB cable

Concrete markers are required only for direct earth buried (DEB) cables. Install a concrete slab marker at each change of direction of DEB cable, over the ends of ducts or conduits which are installed under paved areas and roadways, and over each splice. Markers shall be two feet (2’) square and six inches (6”) thick, and shall be installed within 24 hours of the final backfill of the cable trench. The markers shall be installed flat in the ground with the top approximately one

inch (1”) above the finished grade. Install slabs so that the side nearest the inscription on top includes an arrow indicating the side nearest the cable. Provide color, type, and depth of warning tape.

Concrete shall have a compressive strength of not less than 20 MPa (3000 psi) and have a smooth, troweled finish on the exposed surface. After the concrete marker has set a minimum of 24 hours, the top surface shall be painted bright orange with paint manufactured specifically for uncured exterior concrete. Markers shall not be installed in concrete or asphalt surfaces.

Each cable marker shall have the following information impressed upon its top surface:

a. The word “CABLE”.

b. Name of facility served; for example, “ASR,” “VORTAC,” “ALS,” etc.

c. The designation of the type of cables installed shall be shown on the marker. The type shall be marked with the following abbreviations: “P” for Power, “C” for Control, “T” for Telephone, and “R” for Coaxial (Radio Frequency).

d. An arrow to indicate the direction or change of direction of the cable run.

e. Any additional information as defined by the contract drawings.

f. The contractor shall obtain authorization from the FAA for the information to be impressed on the cable marker and for the method of impression. The letters shall be four inches (4”) high, three inches (3”) wide and one half inch (1/2”) deep.

All cable and cable markers shall be coded with applicable color coding standards, as applicable to the locality. If no standard applies, use the American Public Works Association (APWA) color codes shown in Table VI.

TABLE VI. APWA color codes.

COLOR CODE	TYPE OF UNDERGROUND UTILITY
RED	Electric power lines, cables or conduits, and lighting cables
YELLOW	Gas, oil, steam, petroleum or other hazardous liquid or gaseous materials
ORANGE	Communications, cable TV, alarm or signal lines, cables, or conduits
BLUE	Potable water lines
GREEN	Sewers, storm sewer facilities and utilities, or their drains lines
PURPLE	Reclaimed water, irrigation, or slurry lines
WHITE	Proposed excavation
PINK	Temporary survey marking

The location of the ends of ducts shall be marked with concrete markers 2 feet (2') square and 6 inches (6") thick. The duct markers are to be installed in the same manner as cable markers, except the following shall be impressed upon their top surface:

a. The word, "DUCT".

b. Name of facility served; for example, "ASR," "VORTAC," "ALS," etc.

c. An arrow to indicate the direction or the change in direction of the cable route.

d. The number of conduits and the type of conduits: for example, 4-P/2-C.

e. Any additional information as directed by the FAA project engineer.

DEB cables shall be marked every two hundred feet (200') along a cable run, at each change of direction of the cable, and at each cable splice. Markers shall be either concrete or other type, or a combination of both as specified in the contract documents.

The markers used for DEB cables shall be impressed with a "P" for power cable.

5.13.2 Special-purpose and near-surface markers

Special-purpose and near-surface markers are used to indicate points of additional information. At a minimum, markers shall indicate the location of splices and the entrances of separate duct banks and/or bores. Other significant points may be required as field-determined. Appropriate-colored surface markers shall also be placed where crossing other utilities (for example, blue for water, orange for telephone, yellow for gas). Markers shall be either drilled into existing surfaces (for example, concrete edge of manhole or pavement) or set in a concrete slab square as above.

5.14 Acceptance and inspection procedures

After the installation of cable systems is completed, the FAA and/or its contractor shall perform acceptance/commissioning testing (refer to Appendix C). All safety procedures for energizing the systems following installation shall follow OSHA confined spaces regulations and NFPA 70E. Tests shall be conducted in the operational environment to confirm operational readiness of the ELD and to identify safety hazards involving any component of the ELD system that will support a system in the NAS.

If applicable, participants shall include the FAA project manager, project engineer(s), contract technical representatives, environmental, safety, real estate, power company contracts representative, airport authority representative, and airport staff.

Once acceptance tests are completed and the results accepted, the FAA shall take beneficial occupancy of the ELD system. This may occur in stages.

APPENDIX A—Surge Arrester Performance Data

1. SCOPE

This appendix provides surge arrester performance data for FAA medium-voltage (MV) electrical line distribution (ELD) systems. Surge arresters protect the following ELD system elements:

a. Overhead lines and distribution transformers (utility responsibility),
b. MV transformers and cable installations,
c. MV cables,
d. Internal switchgear and sectionalizers in MV networks,
e. Other ELD-related special-purpose applications as required.

2. APPLICABLE DOCUMENTS

2.1 Non-government publications

Institute of Electrical and Electronics Engineers (IEEE)

IEEE C62.11 (2005; And 1 2008)
Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)

Guide Information for Electrical Equipment, The White Book 2011, and UL Product Categories Correlated to the 2008 and 2011 National Electrical Code®. Surge Arresters 1000 Volts and Higher (VZQK)

National Electrical Manufacturers Association (NEMA)

NEMA LA 1 (1992; R 1999) Standard for Surge Arresters

National Fire Protection Association (NFPA)

NFPA 70 (2008; TIA 08-1) National Electrical Code

NEC article 280: Introduces surge arresters, general requirements, installation requirements, and connection requirements.

3. REQUIREMENTS

3.1 Performance Requirements

3.1.1 General

The requirement is for high-quality metal-oxide surge arresters for use in FAA-owned distribution networks to ensure the protection of underground power cables, low-level distribution transformers, generators, sectionalizing switches, and other electrical equipment. Surge arresters limit dangerous voltage surges caused by lightning strikes or switching anomalies occurring in the ELD network. Arresters also increase the availability of power by reducing outages. Voltage surges can result in personnel injuries from electrical shock, insulation damage to equipment, and possibly fire. Surge arresters provide safe dissipation of these surges.

The standard root-mean-square (rms) maximum continuous operating voltage (MCOV) and rms duty-cycle voltage ratings for typical nominal voltage values and configurations used in FAA underground electrical distribution systems (except note 1) are shown in the table below. Light-duty surge arresters in common use in FAA ELD systems correspond to these configurations.

Nominal Voltage (KVrms)	MCOV (KVrms)	Duty-Cycle (KVrms)
4,160Y (3φ) 2,400 (1φ)	5.1 KV 2.55 kV	6 KV 3 kV
13,200Y(3φ) 7,620 (1φ)	15.3 KV 7.65 kV	18 KV 9 kV
4,160Δ (3φ)(see note 1)	5.1	6 kV
13,800	15.3 kV	18 kV

Note (1): The delta configuration is not a typical FAA ELD configuration. If you encounter this configuration or any configuration not shown above, call the Power Cable Program Office, AJW-22, for guidance.

3.1.2 Placement

Surge arresters shall be provided on the line side of:

1. Pole-mounted transformers (utility responsibility in most cases),

2. Overhead to underground terminal poles (utility),

3. All “normally open” switchways of pad-mounted sectionalizing switches connected to and served from overhead lines, THERE ARE NONE. ELIMINATE? ASK MATT M. AT IMCORP

4. Underground primary metering installations connected to and served from overhead lines.

5. On the line side of any location where a voltage/facility transition occurs.

3.1.3 IEEE Standard C62.11

The design, fabrication, testing, and performance requirement to which a medium voltage surge arrester shall comply is IEEE C62.11 (reference provided above). The definition provided in IEEE C62.11 for metal-oxide surge arresters for ac power circuits greater than 1 kV is:

> **Arrester, distribution, light duty class:** An arrester normally installed on and used to protect underground distribution systems where the major portion of the lightning stroke current is discharged by an arrester located at the overhead line/cable junction.

This class of surge arrester conforms to the minimum recommended level to provide protection against switching and other transient voltages in the underground ELD infrastructure. Light duty class arresters are constrained by the prescribed test requirements of standard IEEE C62.11 (see table below).

Surge arrester test requirements

Class	Rated voltage (kV)		Lightning impulse classifying current (kA)	Minimum High current Short duration withstand (kA)	Minimum Low current Long duration withstand (A, μs)
	Duty cycle	MCOV			
Distribution, light duty	3–36	2.55–29	5	40	75, 2000

3.1.4 Service conditions

An arrester installed in the FAA ELD system shall be capable of successful operations under the service conditions given in the paragraphs below.

3.1.4.1 Usual service conditions

Physical conditions

a) Ambient air temperature in the general vicinity of the arrester shall be between –40°C and +40°C except that: (1) Ambient air temperature in the general vicinity of dead front arresters shall be between –40 °C and +65 °C, and (2) Ambient liquid temperature in the general vicinity of liquid-immersed arresters shall be between –40°C and +95°C.
b) Maximum temperature of the arrester, due to external heat sources in the general vicinity of the arrester, shall not exceed 60°C, except that (1) Maximum temperature of the dead front arrester shall not exceed 85°C, and (2) Maximum temperature of the liquid-immersed arresters shall not exceed 120°C.
c) Altitude shall not exceed 1800 m (6000 ft), except for liquid-immersed arresters.

System conditions

a) Nominal power system frequency of 48 Hz to 62 Hz.
b) System line-to-ground voltage within the ratings of the arrester under all system operating conditions.

3.1.4.2 Unusual service conditions. Exposure to any of the service conditions described in the sections below may require special consideration in the design or application of arresters.

Physical conditions

a) Ambient temperatures in the general vicinity of the arrester exceeding the values given in Section 3.1.4.1 above, Physical Conditions.
b) Maximum arrester temperatures exceeding the values given in Section 3.1.4.1 above, Physical Conditions.
c) Altitude exceeding 1800 m (6000 ft). Arresters for service at higher altitudes shall be suitable for operation at either of the following altitude ranges:
   i) 1801–3600 m (6,001–12,000 ft).
   ii) 3601–5400 m (12,001–18,000 ft).
d) Exposure to any of the following:
   i) Damaging fumes or vapors
   ii) Excessive dirt, salt spray, or other current-conducting deposits.
   iii) Steam.
   iv) Explosive atmospheres, abnormal vibrations, or shocks
e) Limitation on clearances to nearby conducting objects, particularly at altitudes exceeding 1800 m (6000 ft)
f) Unusual transportation or storage.

System conditions

a) Nominal power frequency other than 48 Hz to 62 Hz
b) System operating conditions whereby the ratings of the arrester may be temporarily exceeded. Some examples are as follows:
   i) Loss of neutral ground on normally grounded circuit
   ii) Generator overspeed
   iii) Resonance during faults upon loss of major generation
   iv) System instability
   v) Persistent single line-to-ground fault on ungrounded three-phase systems
c) Any other unusual conditions known to the user.

APPENDIX B—Cable Pulling Calculations

This appendix provides basic information on how to calculate maximum pull force during cable pull operations. For detailed information and more elaborate tables, consult the cable manufacturer. Industry software is readily available to assist with these calculations.

1. To calculate cable pulling force for a cable consisting of several segments, and/or where a cable bends around a curve or a number of curves, calculations are done in incremental segments/steps using formulas and tables, with the segments/steps added together to arrive at the cumulative maximum pull tension. Add an additional 15% margin for safety. To illustrate the cumulative method, an example is given: the pull force calculated for a cable segment A is added to a "bend multiplier" AB, a pull force for straight cable segment B, a pull force for cable segment C, a bend multiplier CD, and a cable segment D, etc., plus 15%.

The basic formula for calculating maximum pulling tension in a single cable section is:

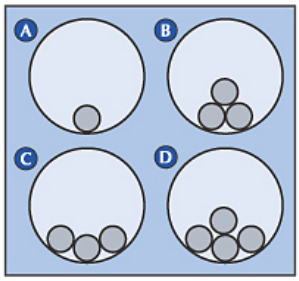
$$T = L \times w \times f \times W,$$

where
T is the total pulling tension (lb),
L is the length (ft) of cable being pulled,
w is the total weight (lb/ft) of the conductors,
f is the coefficient of friction (usually 0.5 for well-lubricated conditions),
W is the weight correction factor.

2. The process for calculating pull force for a segment of a cable run is as follows:

a. Enter the length of the cable segment in the formula above.
b. Enter the weight of the cable segment.
c. Enter the coefficient of friction.
d. Enter the weight correction factor W, derived as follows:
    i. Determine the geometric position of how the cables will lay in the conduit.
    ii. Calculate W using the table below.
e. Check for jamming hazard of the cables in the conduit.
f. Check sidewall bearing pressure (SWBP).
g. Check headroom.

3. The weight correction factor (W) calculation is based on the cable geometry in the duct:



A = Single; B = Triangular; C = Cradled; D = Diamond

To determine cable geometry, use the ratio of the conduit's inside diameter (D) to the cable's outside diameter (d) to find how the single conductors will sit in the conduit:

Triangular (Fig. B): This occurs when pulling three individual conductors from three separate reels, and their D/d ratio is less than 2.5. If pulling individual triplexed conductors from a single reel, the cables will also sit in this position.

Cradle (Fig. C): This position may occur when pulling three individual conductors from three separate reels, and their D/d ratio is between 2.5 and 3.0. This position is the least favorable because it yields the worst-case scenario of drag during the pull.

Diamond (Fig. D): This position occurs when pulling four individual conductors from four separate reels, and their D/d ratio is less than 3.0. If pulling quadruplexed individual conductors from a single reel, the multiconductor cable will also sit in this position.

No. of Conductors	**Position**	**Weight Factor Equation**
1	Single	$W = 1$
3	Triangular	$W = 1 / \{1-[d/(D-d)]^2\}^{1/2}$
3	Cradled	$W = 1 + \{(4/3) \times [d/(D-d)]^2\}$
4	Diamond	$W = 1 + \{2 \times [d/(D-d)]^2\}$
W = Weight correction factor D = Inside diameter of conduit d = Outside diameter of individual conductor		

For the most conservative calculation, use the cradle configuration.

4. Jamming ratio. When sizing the conduit system, installers must consider the possibility of cables jamming or wedging. This usually occurs when three or more individual conductors lie side by side in a single plane. As the conductors are pulled through a bend, the curvature of the bend tends to squeeze the conductors together. Use the following formula to determine the likelihood of jamming. Use the inside diameter of the conduit and the outside diameter of the individual conductor. Avoid jam ratios of 2.8 to 3.2 for Type MV extruded dielectric power cables:

$1.05 \times (D \div d)$

Where
D = the inside diameter of the conduit
d = the outside diameter of an individual conductor.
Constant factor 1.05 = correction for oval shape of bends in the sectional view.

- If the value is less than 2.5, the cable will jam,
- If the value is less than 3.0 but greater than 2.8, jamming is very possible,
- If the value is greater than 3.0, jamming will not occur.
- For medium-voltage extruded dielectric power cables, avoid values between 2.8 to 3.2.

5. Sidewall bearing pressure (SWBP). Sidewall bearing pressure (in pounds per foot) is the tension on the cable coming out of a bend (in pounds) divided by the inside radius of the bend (in feet). When pulling at a bend, the recommended maximum sidewall pressures for 15kV class and less is 500 lb/ft (or less, if recommended by the manufacturer).

No. of Conductors	**Position**	**SWBP Equation**
1	Single	SWBP = T ÷ R
3	Cradled	SWBP = [(3W – 2) x T] ÷ 3R
3	Triangular	SWBP = (W x T) ÷ 2R
4	Diamond	SWBP = (W – 1) x (T ÷ R)
W = weight correction factor; T = calculated tension; R = radius of bend (inside radius).		

6. Headroom. To ensure a safe and easy pull, provide clearance between the uppermost conductor and the top of the conduit. For straight pulls, a clearance as small as ¼ in. is considered safe. For more complex pulls, between ½ in. and 1 in. is required. Use the equations below to derive the clearance for a given conduit and cable sitting position. Note that allowance is made for variations in cable and conduit diameters, and the oval shape of the raceway sections at bends.

Configuration	**Clearance**
Single	$C = D' - d'$
Triangular	$C = \left[\sqrt{D' - 1.366\,d'} + \sqrt{(D' - d')}\right] \times \sqrt{[1 - (d' \div D' - d)^2]}$
Diamond	$C = \left[(D' - d') - 2d'^2\right] \div (D' - d')$
C = Clearance, D´ = 1.05 x nominal conduit inside diameter; d´ = 1.05 x nominal overall diameter of individual conductor.	

7. Limit pulling tension to 0.008 lb/cmil for copper conductors pulled by pulling eyes or pulling bolts (pulling tension applied directly to the conductor).

8. Limit pulling tension to 1000 lb for jacketed cables pulled by cable grips.

9. Angle of bend. Every time there is a bend in the cable, a bend multiplier factor must be introduced:

Bend Angle	Multiplier
15	1.14
30	1.30
45	1.48
60	1.70
75	1.94
90	2.20
105	2.50
120	2.86

10. For steel, wire, rope, or tape used for cable pulling, a dynamometer graduated to indicate the tension on the cable being pulled can be used, or the contractor shall adapt a rope harness properly sized to limit pull tension to the value indicated. Any combination of a group of cables to be pulled into a duct shall not exceed the sum of individual allowable tension of each cable plus 15 percent.

APPENDIX C—Acceptance testing of newly installed FAA medium voltage underground power cables

This appendix specifies *acceptance testing* of newly installed FAA insulated underground medium voltage power cables rated 2 kV to 15 kV, shielded, non-shielded, and armored. It does not cover *installation testing* or *maintenance testing* as defined in IEEE 400.2. Nor does it cover testing of older, in-service cables. For comprehensive treatment of the maintenance testing of FAA power cables, refer to FAA Order 6950.22, *Maintenance of Electrical Power Cables.*

The testing guidance below applies to both direct burial cables and cables installed in nonmetallic and metal conduit. This appendix covers four types of tests used for validating acceptance of FAA medium voltage cables and accessories: (1) a continuity test, (2) an insulation resistance test; (3) an AC VLF field test; and (4) an offline 50/60 Hz partial discharge test. At a minimum, tests one through three (continuity, insulation resistance, and VLF withstand tests) shall be employed as acceptance tests of new FAA cable installations. Test four (offline PD test) is a state-of-the art test that provides the most thorough and exacting test data of all the choices. It can be substituted for the VLF withstand test if funding is available. The test must be conducted by a qualified third-party testing firm that is preapproved by the FAA, and requires extra lead time in planning the test activity (3 months).

Any newly installed cable that fails as a result of cable acceptance testing shall be replaced by the installation contractor at the installation contractor’s expense.

The paragraphs that follow detail each test’s theory of operation, parameters and tolerances, test schedules, and safety and test procedures. If any conflicts arise relating to power cable testing parameters, procedures, or safety as presented in this appendix, the guidance of FAA Order 6950.22 shall take precedence.

SAFETY REQUIREMENTS, GENERAL

The following are general safety requirements for all electrical power cable acceptance tests. Safety requirements particular to each test are provided in the tests’ respective sections that follow.

Before testing is performed, ensure that cables and associated terminations are isolated from electrical apparatus such as power transformers, potential transformers, surge arresters, capacitors, etc. Cables are allowed to be connected to switches and fused cutouts as long as the switch isolates the cable and terminations from electrical apparatus mentioned above. Maintain at least a 6-inch clearance between cable ends and any grounded surface. If modular "load break" elbow terminations are used on the cable, ensure that the load break elbows are inserted in the associated isolated parking bushings.

Ensure that all cables and terminations are disconnected and isolated from all sources of power. Using proper high-voltage test instruments, verify that the conductors are not energized and there is no back-feed from some unknown source.

Ensure that all cable shields, equipment grounding conductors, armor, and metallic conduits are properly grounded to the earth electrode system at both ends of the cable to be tested. If present, check to ensure that the cable shield, armor, and equipment grounding conductors are electrically continuous from one end of the cable to the other.

Refer to FAA Order 6950.22, Chapters 1 (Para. 105), 2 (Para. 220, 221, 222), and 5 (Para. 504), as well as applicable IEEE standards for more safety guidance.

1. INSULATION RESISTANCE TEST

1.1 Theory of Operation

After cable system installation and before the cable system is placed in normal service, a "limited voltage" DC insulation resistance test shall be performed and documented, including the testing of terminations and joints.

The insulation resistance test is classified by the IEEE as a diagnostic test. The purpose of the test is not to ensure the cable systems' future performance but simply to assure the construction team that the line is not grounded/shorted before energization. Insulation or dielectric resistance is the resistance to the flow of direct current through or over the surface of the insulating material. Cables are tested by measuring the resistance between conductors, and the resistance between each conductor and ground. For a new cable, or one that is believed to be in very good condition, all of these resistances should measure in megohms (for tolerances, see Section 1.2 of this appendix below).

Any insulation resistance values less than 50 megohms shall be investigated. Note that the insulation resistance values may be affected by temperature, cable geometry, cable length, and leakage along cable terminations.

The installation contractor shall be responsible for repair/replacement of any failed components and retest costs.

1.2 Parameters and Tolerance limits

For test parameters and tolerance limits, refer to FAA Order 6950.22, *Maintenance of Electrical Power Cables,* Chapter 3, *Standards and Tolerances,* Paragraph 301, Table (see column heading labeled "NEW CABLE").

1.3 Test Schedules

Test after installation and just before energizing the new system.

1.4 Safety and Test Procedure

1.4.1 Safety

Follow safety practices as set forth in Chapter 2 (Para. 221e[2][c]) and 5 (Para. 502, 503) of FAA Order 6950.22, *Maintenance of Electrical Power Cables.* Refer also to the paragraphs that follow, and IEEE standards, for additional safety and grounding procedures.

Before testing begins, ensure that all associated cable shields, armor, equipment grounding conductors, and metallic conduit are properly grounded at both ends to an approved earth grounding systems or electrode. Verify that the conductors are not energized.

Ensure that cable shields and/or armor are electrically continuous by performing a simple resistance measurement using a reliable and calibrated digital multimeter. Ensure that all insulated conductors in the cable assembly that are not to be tested, as well as adjacent cables, are properly grounded at both ends to prevent capacitive voltage build-up.

When testing, one or more cable ends will need to be remote from the testing site. Therefore, before testing is begun, cables ends under test must be cleared and guarded. Switches and fused cutouts and circuit breakers used for isolating the cable under test shall be identified, locked, and tagged out of service. If possible, remote ends of cable being tested should be enclosed in a locked enclosure, vault, room, or other location accessible to qualified personnel only. All testing shall be performed between earth/ground and each insulated conductor, and between each insulated conductor.

Insulation testing must comply with OSHA regulations, Standard for Electrical Safety in the Work Place (NFPA-70E), and the National Electrical Safety Code (ANSI C2). ***All medium/high voltage testing must be performed by TWO individuals.*** Before, during, and after testing, ensure that all applicable safety rules are followed, including the use of proper personal protection equipment (PPE), lockout/tagout of all associated electrical energy sources, testing cables for possible “backfeed” from unknown electrical sources, and discharge of residual capacitive charges on cables to be tested.

Use only the approved high-voltage power test instruments to check for AC and DC voltages on all cables. ***DO NOT use hand-held test instruments which are only rated (or used in electrical/electronic applications) at 1,000 volts or less.***

1.4.2 Test Procedure

Refer to FAA Order 6950.22, Chapter 5, Para. 503 for detailed test procedures. The test procedures cover new cables having either 100% or 133% cable insulation ratings. In instances where the new cable to be tested is joined to an older cable, consult with the FAA project engineer to adjust the testing parameters as needed.

CAUTION: After all tests are complete and before the cables and terminations are placed back into normal operation, ENSURE that all temporary safety grounding connections are removed from all insulated conductors that will be energized.

1.4.2.1 New 2,000 to 5,000 Volt Cables, Terminations, and Joints

Insulation resistance baseline measurements shall be taken and documented after cable system installation, including terminations and joints, but before the cable system is placed in normal service. Test with a 5,000 volt insulation resistance test set (AEMC Instruments Type 5070 or approved equal) applied incrementally up to the voltage rating of the cable for a duration of not to exceed 5 minutes. Do not exceed the rms line-to-ground voltage across the conductor and metallic shield. Record the resistance at each voltage level as well as the ambient temperatures and relative humidity. Perform insulation resistance testing from each insulated conductor to ground and between each insulated conductor (ref FAA Order 6950.22). Because of possible power capacity limitations of the test set, the maximum length of the cable to be tested shall be based on the manufacturer's testing data and the capability of the test equipment. Any insulation resistance values less than 50 Megohms shall be investigated. Note that the insulation resistance values may be affected by temperature, cable geometry, cable length, and leakage along cable terminations. Terminations shall be thoroughly cleaned and, if required, a guard circuit shall be used at the termination. The installation contractor shall be responsible for repair/replacement of any failed components and retest costs.

1.4.2.2 New 15,000 Volt Cables, Terminations, and Joints

Insulation resistance baseline measurements shall be taken and documented after cable system installation, including terminations and joints, but before the cable system is placed in normal service. Test with a 5,000 volt insulation resistance test set (AEMC type 5070 or approved equal) applied incrementally up to 5,000 volts for a duration not to exceed 5 minutes. Record the resistance at each voltage level as well as the ambient temperatures and relative humidity. Perform insulation resistance testing from each insulated conductor to ground and between each insulated conductor (ref FAA Order 6950.22). Because of possible power capacity limitations of the test set, the maximum length of the cable to be tested shall be based on the manufacturer's testing data and the capability of the test equipment. Any insulation resistance values less than 50 Megohms shall be investigated. Note that the insulation resistance values may be affected by temperature, cable geometry, cable length, and leakage along cable terminations. Terminations shall be thoroughly cleaned and, if required, a guard circuit shall be used at the termination. The installation contractor shall be responsible for repair/replacement of any failed components and retest costs.

2. AC VLF FIELD TEST

2.1 Theory of Operation

The AC Very Low Frequency (VLF) (0.1 Hz sinusoidal) field test is essentially a DC Hipot test with a slow voltage oscillation to prevent the buildup of space charge in the cable insulation. The purpose of the test is not to ensure cable system future performance but simply to reassure the construction team that the line is not grounded/shorted before energization. The test is classified

by the IEEE as a destructive test because it is designed to bring a cable and/or accessory to failure where severe defects are present. Thus, the VLF withstand test is a pass/fail test and provides no localization or severity data other than the obvious outward sign of a defect upon failure. Only properly qualified persons who are VLF test-certified may perform this test on FAA ELD systems.

VLF withstand testing is performed after insulation resistance testing. Even if prior insulation resistance testing has indicated that the cable is in good condition, the VLF test may provide a further indication of cable reliability.

Because VLF testing can cause a severe defect in a cable, joints, and/or terminations to fail, provisions should be made to have personnel on-site to find the defective/faulted cable or termination and make the required repairs. Retest the cable after the repairs. Repeat this procedure until cable and terminations pass the VLF test. The installation contractor shall be responsible for repair or replacement of any failed components and retest costs.

2.2 Parameters and Tolerance Limits

For test parameters and tolerance limits, refer to FAA Order 6950.22, *Maintenance of Electrical Power Cables,* Chapter 3, *Standards and Tolerances,* Paragraph 301, Table (see column heading labeled “NEW CABLE”). Also consult IEEE 400.2, *IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF).*

2.3 Test Schedules

Test after installation and just before energizing the new system.

2.4 Safety and Test Procedure

2.4.1 Safety

Follow general safety practices as set forth in Chapters 1, 2, and 5 of FAA Order 6950.22, *Maintenance of Electrical Power Cables.* Refer also to IEEE 400.2 for safety and grounding procedures, and to the paragraphs below.

VLF testing must comply with OSHA regulations, Standard for Electrical Safety in the Work Place (NFPA-70E), and the National Electrical Safety Code (ANSI C2). ***All medium/high voltage testing must be performed by TWO individuals.*** Before, during, and after testing, ensure that all applicable safety rules are followed, including the use of proper personal protection equipment (PPE), lockout/tagout of all associated electrical energy sources, testing cables for possible "backfeed" from unknown electrical sources, and discharge of residual capacitive charges on cables to be tested.

Before testing is performed, ensure that all cables and associated terminations are disconnected and isolated from all sources of power, including electrical apparatus such as power transformers, potential transformers, surge arresters, capacitors, etc. Cables are allowed to be connected to switches and fused cutouts as long as the switch isolates the cable and terminations from the electrical apparatus mentioned above. Maintain at least a 6-inch clearance between cable ends and any grounded surface. If modular load-break elbow terminations are used on the cable, ensure the load-break elbows are inserted in the associated isolated parking bushings. Verify that the conductors are not energized and there is no back-feed from some unknown source.

Properly ground all associated cable shields, armor, equipment grounding conductors, and metallic conduit at both ends to an approved earth grounding systems or electrode. Ensure that cable shields and/or armor are electrically continuous from one end of the cable to the other by performing a simple resistance measurement using a reliable and calibrated digital multimeter. Ensure that all insulated conductors in the cable assembly that are not to be tested, as well as adjacent cables, are properly grounded at both ends to prevent capacitive voltage build-up.

When testing, one or more cable ends will need to be remote from the testing site. Therefore, before testing is begun, cables ends under test must be cleared and guarded. Switches and fused cutouts and circuit breakers used for isolating the cable under test shall be identified, locked, and tagged out of service. If possible, remote ends of cable being tested should be enclosed in a locked enclosure, vault, room, or other location accessible to qualified personnel only.

All testing shall be performed between earth/ground and each insulated conductor, and between each insulated conductor. Use only the approved high-voltage power test instruments to check for AC and DC voltages on all cables. ***DO NOT use hand-held test instruments which are only rated (or used in electrical/electronic applications) at 1,000 volts or less!!!***

2.4.2 Test Procedure

If the new cable to be tested is joined to an older, in-service cable segment, consult with the FAA project engineer for guidance. The test voltage or other parameters may need to be adjusted for in-service cables because they are more sensitive to the high voltage levels attained during the test. Likewise, consult the FAA project engineer if two cable segments of different voltage ratings are being tested simultaneously, as the lower rated cable could be damaged by high voltage levels used to test the higher rated segment.

VLF testing is not required for cables with rated voltages less than 5,000 volts.

2.4.2.1 5,000 Volt Cables

For new 5,000 volt cables and terminations, the AC VLF field acceptance test shall be applied at not to exceed 14,000 volts (peak) for a duration of 15 minutes. This covers cables with both 100% and 133% cable insulation ratings. Record the pass or fail condition at the end of the test along with the ambient temperature and relative humidity. ***Because of possible power capacity limitations of the test set, the maximum length of the cable to be tested shall be based on the manufacturer's testing data and the capability of the test equipment.***

2.4.2.2 15,000 Volt Cables

For new 15,000 volt cables and terminations, the AC VLF field acceptance test shall be applied at 28,000 volts (peak) using a VLF test set (High Voltage Inc., type VLF-28CM or approved equal) for a duration of 15 minutes. This covers cables with both 100% and 133% cable insulation ratings. Record the pass or fail condition at the end of the test along with the ambient temperature and relative humidity. ***Because of possible power capacity limitations of the test set, the maximum length of the cable to be tested shall be based on the manufacturer's testing data and the capability of the test equipment.***

CAUTION: After all tests are complete and before the cables and terminations are placed back into normal operation, ENSURE that all temporary safety grounding connections are removed from all insulated conductors that will be energized.

3. OFFLINE 50/60 Hz PARTIAL DISCHARGE TEST

3.1 Theory of Operation

The offline 50/60 Hz partial discharge (PD) test can identify the location and severity of a defect within the new cable or its accessories, including a latent defect missed by hipot tests.
The test uses a 50/60 Hz high-voltage power source and sophisticated signal processing/analysis to detect minute partial discharges (PD) in cable insulation, pinpointing manufacturing weaknesses and workmanship errors. It is a reliable method for detecting defects inadvertently missed during factory tests, defects introduced during transportation and installation, and flaws introduced while handling and splicing the cables. These defects frequently do not appear in normal voltage withstand tests but can eventually cause undesirable service failures weeks, months, or years into the future.

The test is classified by the IEEE as a diagnostic test and not a destructive test (i.e., it is not designed to cause cable and accessories to fail). Due to its requirements for specialized test equipment, signal processing software, and diagnostic skills, the test must be conducted by a third-party testing firm. The testing firm must be a qualified contractor preauthorized by the FAA.

3.2 Parameters and Tolerance Limits

The test is conducted in accordance with IEEE 400.3 using a maximum test voltage of 2.0 to 2.5 times operating voltage level (Uo) for a duration not to exceed 30 seconds.

For test parameters and tolerance limits, refer to FAA Order 6950.22, Maintenance of Electrical Power Cables, Chapter 3, Standards and Tolerances, Paragraph 301, Table (see column heading labeled "NEW CABLE").

3.3 Test Schedules

Test after installation and just before energizing the new system. Allow adequate lead time for test planning with the third party testing firm: about 3 months before project completion for the initial notice, followed by 8 weeks' advance notice for setting up the information-gathering and detailed planning sessions.

3.4 Safety and Test Procedure

3.4.1 Safety

The third-party testing firm shall provide safety briefings at the beginning of each test session. See FAA Order 6950.22, Chapter 5, paragraph 504e(1) and applicable IEEE safety standards.

3.4.2 Test Procedure

For test procedure details, refer to FAA Order 6950.22, Maintenance of Electrical Power Cables, Chapter 5, Paragraph 504.

CAUTION: After all tests are complete and before the cables and terminations are placed back into normal operation, ENSURE that all temporary safety grounding connections are removed from all insulated conductors that will be energized.

APPENDIX D—Acronyms/glossary

AASHTO	American Association of State Highway and Transportation Officials
AC	Alternating Current Advisory Circular
AJW-22	FAA Power Services Group
ALS	Approach Lighting Systems
ANSI	American National Standards Institute
APWA	American Public Works Association
ASCE	American Society of Civil Engineers
ASR	Air Surveillance Radar
ASTM	American Society for Testing and Materials
AWG	American Wire Gauge. A standard for expressing wire diameter. As the AWG number gets smaller, the wire diameter gets larger.
C	Clearance (cable pulling)
°C	Degrees Centigrade
CADD	Computer-Aided Design and Drafting
cmil	Circular Mil(s). Area of a wire that is one-thousandth of an inch (.001 inch, one mil) in diameter.
CN	Concentric Neutral
CONUS	Continental United States
CT	Current Transformer
d	Cable Outside Diameter (cable pulling)
D	Conduit Inside Diameter (cable pulling)
D’	D x 1.05 (cable pulling)
DC	Direct Current
DEB	Direct Earth Buried
DLA	Defense Logistics Agency
DOD	Department of Defense
Duct Bank	A set of parallel conduits made of steel, PVC covered, steel, heavy-walled PVC, or thin-walled PVC in reinforced concrete. Duct banks terminate in utility access holes or vaults. If not enclosed in concrete, duct banks must be of thicker material than thin-walled PVC.
EES	Earth Electrode System
ELD	Electrical Line Distribution (System). An underground or overhead electrical distribution system running from a power source to FAA facility load(s). An ELD may include some or all of the following: power cable; transformers; sectionalizers; switchpads; disconnect switches; manholes; hand-holes; utility poles; direct earth buried (DEB) cables; and underground duct banks. Intra-facility wiring, runway edge lighting cables, and FOTS and system cables, such as MALSR or ALSF loop cables are not included as part of ELD.
Electrical Trees	Tree-like growths consisting of non-solid or carbonized microchannels, which can occur at electric field enhancements such as protrusions, contaminants, voids, or water trees subjected to electrical stress for extended time periods. Partial discharges are responsible for electrical tree growth.
EPT	Electrical PVC Tubing

EPC	Electrical PVC Conduit
f	Coefficient of Friction (cable pulling)
FAA	Federal Aviation Administration
FOTS	Fiber Optic Telecommunications System(s)
ft	Feet
GIS	Geographic Information Systems
GPS	Global Positioning System
Grounding Conductor	A conductor used to connect equipment or the grounded circuit of a wiring system to the grounding electrode system.
Grounding Electrode	Copper rod, plate, or wire embedded in the ground for the specific purpose of dissipating electrical energy to the earth.
HAZMAT	Hazardous Materials
HDBK	FAA Handbook
HDPE	High-Density Polyethylene
HH	Hand Hole
HIPOT	High Potential (Test)
Hz	Hertz
ICEA	Insulated Cable Engineers Association
IEC	International Electrotechnical Commission
IECA	Insulated Cable Engineers Association
IEEE	Institute of Electrical and Electronics Engineers
in.	Inch(es)
ISO	International Standards Organization
JO	FAA Order
kg	Kilogram(s)
kV	Kilovolt(s)
L	Length of Cable (cable pulling)
lb	Pound(s)
LV	Low Voltage (Typically 600V and Below for ELD Systems)
m	Meter(s)
MCOV	Maximum Continuous Operating Voltage
MH	Manhole
mH	Millihenry(s)
MIL-STD	Military Standard
MIL-I	Military Specification
mil	Unit of Length, Equal to One Thousandth (10^{-3}) of an Inch (0.0254 millimeter)
mm	Millimeter
MOV	Metal Oxide Varistor
MV	Medium Voltage (600 V to 37.5 kV)
NAS	National Airspace System
NEC	National Electrical Code
NECA	National Electrical Contractors Association
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code

NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratory
OPR	Office of Primary Responsibility
OSHA	Occupational Safety and Health Administration
Pa	Pascal(s)
pC	Picocoulomb(s)
PD	Partial Discharge
PPE	Personal Protective Equipment
psi	Pounds per Square Inch
PSG	Power Services Group
PTFE	Polytetrafluoroethylene (Teflon™)
PVC	Polyvinyl Chloride
PWRFRQ	Power Frequency (Test)
Qualified Person (Electrical)	A person knowledgeable in the construction and operation of electric power generation, transmission, and/or distribution equipment, along with associated hazards. Also known as “qualified worker.”
R	Radius of Bend (cable pulling)
rms	Root Mean Square
RMC	Rigid Metal Conduit
RSA	Runway Safety Area. Areas of a runway established to enhance safety in the event of an aircraft undershoot, overrun, or excursion from the side of the runway.
SDR	Standard Dimensional Ratio
SPD	Surge Protection Device
STD	FAA Standard
SWBP	Sidewall Bearing Pressure (cable pulling)
T	Total Pulling Tension (cable pulling)
TR-XLPE	Tree-retardant XLPE
TSA	Taxiway Service Area
U_o	Operating Voltage, Line to Ground
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specification (DOD). The UFGS was founded by the Secretary of Defense and mandated by the Department of Defense for all Military Services to unify their specifications into one database.
UL	Underwriters’ Laboratory
UV	Ultraviolet
V	Volt(s)
VLF	Very Low Frequency
VORTAC	VOR/Tactical Air Navigation
w	Weight of Conductors (cable pulling)
W	Weight correction factor (cable pulling)
Xfmr	Transformer
XLPE	Cross-Linked Polyethylene

APPENDIX E--Submittals Matrix

Contractor-generated design data	
• **Code analysis (e.g., voltage drops, clearance calculations, design arc flash study, etc) (ANSI C2)**	**A Required.**
• **Design assumptions and parameters (FAA-STD-032)**	**B ☐ Required for this project (check block).**
• **Test reports and findings (e.g., soil resistivity, load bearing, frost analysis, etc)**	**C ☐ Required for this project.**
• **Design calculations (FAA-STD-032)**	**A Required.**
• **Contractor-generated design drawings or sketches.**	**A Required.**
Cost estimates	**A Required.**
Medium voltage cable	**A Required.**
Medium voltage cable splices and joints*	**A Required.**
Medium voltage cable terminations*	**A Required.**
Conduits	**A Required.**
Duct construction materials (e.g., concrete, alternatives to concrete where approved, fills and layers, etc)	**A Required.**
Switch pads and sectionalizers	**A Required.**
Transfer switches (automatic and manual)	**A Required.**
Transformers	**A Required.**
Surge arresters	**A Required.**
Live end caps or protective caps	**A Required.**
Precast concrete structures	**A Required.**
Sealing Material	**B ☐ Required for this project.**
Manhole frames and covers	**A Required.**
Hand hole frames and covers	**A Required.**
Cable supports (racks, arms and insulators)	**A Required.**
Protective devices and coordination study	**A Required.**
As-built arc flash hazard study. Required when an existing study is not available, or if modifications are being made to the existing ELD system.	**A Required.**

Electrical equipment factory test reports		
Medium voltage cable factory certified test result report as per FAA-E-2793, Section 4.2 (includes meeting ICEA S-94-649, Sections 4.3.2.1 and 9.13).	A	Required.
Transformers	A	Required.
Switchgear, sectionalizers	A	Required.
Disconnects	A	Required.
Other components	B ☐	Required for this project.
Field acceptance checks and tests (see Appendix C)	A	Required.
Arc-proofing test for cable fireproofing tape	C ☐	Required for this project.
Cable installation plan and procedure		
• Site layout drawing with cable pulls numerically identified	B ☐	Required for this project.
• list of equipment used, with calibration certifications	A	Required.
• The manufacturer, type, and quantity of lubricant used on pull	B ☐	Required for this project.
• The cable manufacturer and type of cable	A	Required.
• The dates of cable pulls, time of day, and ambient temperature	C ☐	Required for this project.
• The length of cable pull and calculated cable pulling tension (calculated value, not maximum value). A single generic table of cable pulls may be submitted.	A	Required.
• The actual cable pulling tensions encountered during pull	A	Required.
• Certificates (tensiometer calibration, VLF tester calibration, etc) [A]	A	Required.
Cable splicer/terminator qualifications* [A]	A	Required.
Cable installer qualifications* [A]	A	Required.
Project design drawings [A]	A	Required.

APPENDIX F—HDPE-to-HDPE and HDPE-to-PVC Conduit Adhesive - Sample Product

BonDuit®

Conduit Adhesive

American Polywater's

BONDS to Polyethylene, PVC, Fiberglass, Metals and more

BonDuit® Conduit Adhesive is a unique two-part adhesive system used to transition-splice conduits (innerducts) of different types. BonDuit® Adhesive in 5 minutes makes a strong, durable splice that is air/water tight. Requires no expensive equipment.

Estimated Load Capacity and Usage

Conduit Diameter	Polyethylene Conduit to PVC Standard Coupling	
	Coupling length	Pullout Force
1 inch	2 ⅞ inch	760 lbs_f
1 ½ inch	2 ⅞ inch	1,140 lbs_f
2 inch	2 ½ inch	1,520 lbs_f
4 inch	3 ¾ inch	4,560 lbs_f

Results are based on careful surface preparation and a 24-hour cure at 70° F. Under these cure conditions; the load will reach 50% capacity after one hour and fully cured in 24 hours. To create air-tight joints for air-assisted cable installation, a cure time of 2 hours at 70°F is recommended. BonDuit® Conduit Adhesive is not designed for high stress pulls, such as those in HDD installations.

Numbers of Applications

BonDuit® Conduit Adhesive kit contain the materials necessary to prepare plastic and metal surfaces for bonding. By following the instructions, a strong joint takes just minutes. Each cartridge contains enough material for numerous applications, depending on the size of each coupling or joint.

Conduit Size	Applications per Cartridge
1 inch	20-30
1 ½ inch	12-18
2 inch	10-15
4 inch	4-6

FAA-E-2042c
November 19,1998
Supersedes
FAA-E-2042b
January 21, 1983

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION SPECIFICATION

CABLE, ELECTRICAL CONTROL, EXTERIOR

1. SCOPE.

1.1 Scope. - This specification covers the requirements for various types of exterior multi-conductor cables, paired and unpaired, individually shielded or overall shielded that are used for control. They will have either polyvinyl chloride, polyethylene or ethylene propylene rubber insulation, a moisture resistant compound filled core and an overall shield or armor, if specified, and a polyethylene or polyvinyl chloride jacket.

1.2 Classification. - Four types of cable are covered by this specification:

Type 1A - AWG 18 or 22 twisted shielded pair conductors with polyvinyl chloride, polyethylene or ethylene propylene rubber insulation rated at 300 volts, each pair individually shielded having an overall jacket suitable for duct or overhead installation.

Type 1B - AWG 18 or 22 twisted shielded pair conductors with polyvinyl chloride, polyethylene or ethylene propylene rubber insulation rated at 300 volts, each pair individually shielded and having an armor and outer jacket suitable for DEB direct earth burial.

Type 2A - AWG 18 through AWG 8 unpaired conductors, with polyvinyl chloride, polyethylene or ethylene propylene rubber insulation rated at 600 volts, having an overall shield, and an outer jacket suitable for duct or overhead installation.

Type 2B - AWG 18 through AWG 8 unpaired conductors, with polyvinyl chloride, polyethylene or ethylene propylene rubber insulation rated at 600 volts, with an overall shield, an armor, and an outer jacket suitable for direct earth burial DEB.

2. APPLICABLE DOCUMENTS and INDUSTRIAL STANDARDS. - The following documents form a part of this specification, and are applicable to the extent specified herein.

2.1 International Organization for Standardization (ISO).

ISO 9003	Model for Quality Assurance in Final Inspection and Test.
ISO 10012-1	Quality Assurance Requirements for Measuring Equipment.

2.2 Industry standards.

2.2.1 American Society for Testing and Materials Specifications ASTM.

ASTM D 4566-94	Standard Test Methods for Electrical Performance

2.2.2 Insulated Cable Engineers Association Specification ICEA.

ICEA S-84-608	Telecommunications Cable Filled, Polyolefin Insulated, Copper Conductor
ICEA S-73-532	Standard for Control Cables.
ICEA-T-27-581	Standard Test Methods for Extruded Dielectric Power, Control, Instrumentation and Portable cables. Also called NEMA WC 53-1983

2.2.3 Rural Electrical Administration REA.

REA BULLETIN PE-39 6/93 1753-205	REA Specification for Filled Telephone Cables.

2.2.4 National Electrical Manufacturers Association Specification NEMA.

WC-26-94 Wire and Cable Packaging Standard

2.3 Precedence of documents. - In the event of a conflict between the above-mentioned documents and this specification, this specification shall govern. Copies of the above documents may be obtained as follows:

2.4 Document sources.
Copies of this specification may be obtained from the Federal Aviation Administration office issuing the invitation for bids, Attention: Contracting Officer. Requests should fully identify material desired, i.e., specification number, date, amendment number; also, requests should state the contract involved, or other use to be made of the requested material.

ASTM Specifications may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ICEA Specifications may be obtained from the Insulated Cable Engineers Association, P.O. Box P, South Yarmouth, MA 02664.

NEMA Specifications may be obtained from the National Electrical Manufacturers Association, 2101 L Street, NW, Washington, D.C. 20037.

ISO standards may be obtained from the American National Standards Institute, ANSI, 11 West 42 Street, 13th floor, New York, 10036 NY.

REA specifications may be obtained from the US Department of Agriculture (USDA), Rural Electrification Administration (REA), Washington, and DC 20250-1500.
Publication Office, PDMB, Room 0174-S, AG Box 1533.

3. REQUIREMENTS.

3.1 Materials. - Materials shall be as specified herein. The insulation and jacket materials shall be made from virgin compounds.

3.2 Workmanship. - Cable shall be manufactured and processed consistent with the requirements defined in ICEA S-73-532. The cable shall be free of any imperfections that may affect its serviceability.

3.3 Design and construction. - The finished cable shall be circular in cross section except where noted otherwise herein.

3.3.1 Conductors. - Each conductor in the cable shall consist of stranded wire, in accordance with ICEA-S-73-532, paragraph 2.3.3

3.3.1.1 Materials. - The conductors shall be soft drawn or annealed copper in accordance with ICEA-S-73-532, paragraph 2.3.1.1.

3.3.1.2 Conductor joints. - Joints made in conductors during the manufacturing process shall have been welded, or brazed using a silver alloy and non-acid flux. Conductor joints shall be free from lumps and sharp protrusions. The tensile strength of any section of a conductor having a factory joint shall be not less than 85 percent of the tensile strength of any section of the conductor without a joint.

3.3.2 Mutual capacitance. - In types 1A and 1B the mutual capacitance shall not exceed 35 pf/ft.

3.3.3 Insulation materials. - Conductor insulation materials shall be polyvinyl chloride (PVC), ethylene propylene rubber (EPR) or polyethylene. A four-mil layer of nylon may be substituted for four mils of the specified thickness of PVC specified in paragraph 3.3.3.1.

3.3.3.1 Insulation thickness. - Insulation thickness shall be in accordance with ICEA S-73-532 Table 3-1.

3.3.3.2 Repairs. - Repairs to the insulation are permitted in accordance with the stipulations in ICEA S-73-532 paragraph 3.3.11 using heat fusing and insulation grade compound or suitable heat shrinkable sleeves.

3.3.4 Conductor identification.

3.3.4.1 Types 1A and 1B. - Conductor identification shall be as stipulated in ICEA S-73-532, Appendix E paragraph E.3.1 (Method 1referencing Table E-2) and paragraph E.3.7 (Method 7 referencing Table E-2).

3.3.4.2 Types 2A and 2B. - Conductor identification shall be as stipulated in ICEA S-73-532, Appendix E paragraph E.3.1 (Method 1referencing Table E-2).

3.3.5 Cabling of core.

3.3.5.1 Forming of pairs. - Type 1A and 1B insulated conductors shall be twisted into pairs in a manner which minimizes the susceptibility to cross talk.

3.3.5.2 Forming of cable. - Cables consisting of two or more twisted pairs or four or more unpaired conductors shall be cabled together with either a right or left hand lay, and where necessary the interstices shall be filled to give the cable a circular cross section.
Flame retardant non-wicking and non-hygroscopic fillers may be used to provide a round cable.

3.3.6 Filler compound. - For type 1B and 2B the cable core shall be filled with a moisture resistant compound which is neither a dermal irritant nor toxic. For terminating or splicing purposes, the compound shall be removable by merely wiping with a dry cloth. The filler shall completely fill the core. If colored, the coloring of the compound shall not interfere with conductor identification. The compound shall be compatible with the conductor insulation, core covering, shield/armor and jacket. The compound melting characteristics shall meet the requirements of paragraph 4.3.5.

3.3.7 Shielding.

3.3.7.1 Shield. - All types shall have either individually shielded pairs or an overall shield consisting of 100 % coverage with aluminum polyester foil shield. Type 1A and 1B shield shall consist of a two-layer tape consisting of a polyester base bonded to aluminum foil.
Type 2A and 2B shall be as stipulated in ICEA S 73-532 paragraph 4.1 through 4.1.3.

3.3.7.2 Drain wire. - For all types, an uninsulated, tinned, copper drain wire shall be included and shall be in continuous contact with the shield. The drain wires shall be as stipulated in ICEA S 73-532 paragraph 4.1.3.1.

3.3.7.3 Shield tape application and drain wire. - The tape shield shall be applied such that the aluminum foil is in continuous electrical contact with the drain wire. For types 1A & 1B cable the shield tape shall be constructed and applied such that contact of the conductive side of the foil of

adjacent pairs does not occur. The shield coverage of the conductors shall be as stipulated in ICEA S 73-532 paragraph 4.1.3.

3.3.8 Armor.

3.3.8.1 General. - Type 1B, and 2B, cables shall have either an armor or a tape applied over the core covering as stipulated in ICEA S 73-532 paragraph 4.3.5 and 4.3.6 before the application of the outer jacket.

3.3.8.2 Armor/cladding. - Type 1B shall have aluminum continuous lightweight exterior (C-L-X) armor construction or better. For type 2B copper clad stainless steel armor shall be as stipulated in ICEA S73-532 paragraph 4.3.6.

3.3.9 Jacket.

3.3.9.1 General. - A jacket shall be applied over the shield or armor in accordance with ICEA S 73-532 paragraph 4.3.7. It shall be free of irregularities as stipulated in ICEA S73-532 paragraph 4.3.7.2.

3.3.9.2 Material. - Type 1A and 1B shall have a jacket of black sunlight resistant PVC. Type 2A and 2B shall have a jacket as stipulated in ICEA S-73-532, paragraph 4.2.

3.3.9.3 Integrity. - Opening of the cable jacket during manufacturing for repair or for any other purpose will not be permitted. Minor jacket defects not in excess of 0.125 inch size in any direction may be repaired by using heat fusing and jacket grade compound.

3.3.9.4 Thickness. - Jacket thickness for types 1A and 1B shall be in the range of 50 mils for (4) pairs to 70 mils for (24) pair cable. For type 2A it shall be as stipulated in ICEA S-73-532 paragraph 4.2.1 and table 4.1. Type 2B shall be as stipulated in paragraph 4.3.7.1 and table 4-11.

3.3.10 Special construction. - Cables containing two shielded groups may have flat oval construction if necessary for manufacturing reasons.

3.4 Cable identification. All cables shall be provided with markings as stipulated in ICEA S-73-532 section 5.4 and Appendix E.

4. QUALITY ASSURANCE PROVISIONS.

4.1 Quality control program. -The contractor shall maintain a quality control program in accordance with ISO 9003 and ISO 10012-1. The contractor shall have a copy of a current qualification test report for a cable of equal or similar construction showing compliance with this specification. The FAA shall have the option to have these tests witnessed by a government representative. The contractor shall furnish certified test reports and the manufacturer's current Qualification Test Report (QTR). Any reel of cable offered for inspection but failing to meet the requirements of the tests for the inspection may not be offered for a retest without the approval of the Contracting Officer.

4.2 Tests to be performed on all completed cables. - All cables to be manufactured in response to an IFB shall be tested at the factory for the parameters specified in the ensuing paragraphs and certified test results shall be submitted to the Government.

4.2.1 Conductor faults. - Each length of cable shall be free of grounds, open circuits, crosses or short circuits.

4.2.1.1 Conductor resistance. - Conductor resistance measurement shall comply with the method described in sections 6.2 of ICEA S-73-532 and 1.1 of ICEA T-27-581.

4.2.2 Mutual capacitance. - Mutual capacitance shall be measured in accordance with ASTM D-4566 section 18.

4.2.3 Voltage withstand test. - In each length of cable the insulation between conductors shall undergo a voltage withstand test as specified in ICEA T-27-581 paragraph 1.2.

4.2.4 Shield test. - The shield and drain wire on each shielded pair for types 1A & 1B as well as the overall shield for types 2A & 2B on each length of cable shall be tested for continuity. Using a foot sample from each reel, no exposure of the conductors shall occur when coiled three times around a mandrel sized a maximum of ten times the diameter of either the pair for type 1A or the cable for type 1B.

4.2.5 Conductor identification. - Verify that conductor identification is in accordance with paragraph 3.3.4 of this specification.

4.2.6 Jacket integrity. - The cable shall be spark tested as per section 6 of ASTM D-4566. The acceptable default rate is to be determined by section 7 of ASTM D4566. All repairable faults (see paragraph 3.3.3.2) shall be tested after repair.

4.3 Qualification tests. - The contractor shall provide, when stipulated by the Government, certified summary records of qualification test results for all cable attributes cited in section 3, or if stipulated in the invitation for bids (IFB) referee samples per the following.

4.3.1 Referee samples. - Samples shall be prepared in accordance with sampling methods and practices cited in REA PE-39, Appendix A, paragraph 2, Qualifications Test Methods Bulletin.

4.3.2 Shipment of samples. - Where the shipment of samples for referee tests is required, such shipment will be at Government expense on a Government bill of lading. Packing of samples and delivery to common carrier shall be at the expense of the contractor.

5. PREPARATION FOR DELIVERY.

5.1 General. - Unless otherwise indicated, each reel shall contain one continuous length of cable within a tolerance of plus 5 minus zero percent per reel.

5.2 Cable reels.

5.2.1 Cable reel construction. - Cable reels shall be new and nonreturnable, and shall comply with the requirements of NEMA WC-26, Wire and Cable Packaging, Table I for wood. The drum diameter shall be a minimum of 24 inches. Plywood reels are not acceptable.

5.2.2 Cable protection. - The reels shall be designed for storage outside in unprotected areas, and shall include provisions for rainwater/moisture drainage when the reels are stored both on end and on side. A layer of reflective material such as white water-resistant paper, white plastic, or aluminum foil shall be placed completely over the outer layer of cable on the reel.

5.2.3 Cable reeling. - The capacity of reels shall be sufficient to allow a spacing of a minimum of two cable diameters between the top layer and the lagging specified in paragraph 5.2.5 of this specification. The cable shall be secured so as to prevent being displaced during shipment.

5.2.4 Oversized reels. - Where the size of the reels required exceeds the maximum size listed in NEMA WC-26, reels shall be constructed consistent with the intent and the requirements of NEMA WC-26. The ends of cable shall be sealed to exclude moisture. Flange cable entry slot and cable ends shall be covered with a minimum of 18-gauge metal plate. Where the gross weight exceeds 2500 pounds, metal reel centers shall be provided.

5.2.5 Reel lagging and strapping. - Reels shall be lagged with nominal two-inch by four-inch # 2 common lumber. Lagging shall be edge to edge around the reel circumference and shall be strapped with two or more steel straps over the lagging.

5.3 Reel marking. - The reel shall be marked with the following information, permanently applied on the flange with ink or paint:

(a) "manufactured in accordance with FAA-E-2042c Type ___".

(b) conductor size, type and number (specify pairs).

(c) year of manufacture.

(d) length of cable, number of pairs.

(e) contractor's name.

(f) contract number under which cable was purchased.

(g) NSN, national stock number (if provided).

(h) name and address of consignee.

6. NOTES. - The subparagraphs below are only for the information of the Contracting Officer (CO). They are intended to assist the CO in formulating a contract. They are not contract requirements, nor binding on either the Government or the contractor, except to the extent that they may be specified elsewhere in the contract as such. The contractor shall not rely on the information in these subparagraphs.

6.1 Items requiring specification in the Invitation for Bids (IFB).

6.1.1 Number and size of conductors. - The IFB must indicate the number of conductors and the size of conductors.

6.1.2 Cable length per reel. - The IFB must include the cable length per reel. The suggested wording for variance in quantity is the following:

> "Cable shall be supplied on nonreturnable reels in continuous lengths of (See paragraph 5.1) XXXX feet plus 5 minus zero percent per reel containing no splices"

6.1.3 Cable pairs. - Procurement provisions should include the number of pairs required per cable.

6.2 Testing.

6.2.1 Factory inspection option. - The IFB shall state that the Government shall have the option of witnessing production tests conducted at the factory (See paragraph 4.1). Regardless of whether the government witnesses the production tests, the contractor shall furnish certified test reports and the manufacturers most recent Qualification Test Report as specified in 4.1.

6.2.2 Referee samples. - The IFB must indicate if and subject to what conditions, referee samples for independent qualification testing will be required.

* * * * * *

FAA-E-2072c
October 29,1998
Supersedes
FAA-E-2072b
January 21,1983

DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION SPECIFICATION

CABLE, TELEPHONE, EXTERIOR

1. SCOPE.

1.1 Scope. - This specification defines the requirements for multi-pair telephone service cable having #19 American Wire Gauge (AWG) or if specified #22 AWG solid copper conductors, polyolefin insulation, a moisture resistant compound filled core and a polyethylene jacket.

1.2 Classification. - Two cable types are covered by this specification:

Type I Multi-pair cable for duct or overhead installation using a messenger cable for support.

Type II Multi-pair cable for direct earth burial or for installation in ducts. This cable shall have a composite shield/armor to provide protection from insects and rodents.

2. APPLICABLE DOCUMENTS and INDUSTRIAL STANDARDS. - The following documents form a part of this specification, and are applicable to the extent specified herein.

2.1 International Organization for Standardization (ISO).

ISO 9003	Model for Quality Assurance in Final Inspection and Test.
ISO 10012-1	Quality Assurance Requirements for Measuring Equipment.

2.2 Industry standards. - The following publications form a part of this specification and are applicable to the extent specified herein.

2.2.1 Insulated Cable Engineers Association (ICEA) Specification.

ICEA S-84-608-1994 Telecommunications Cable, Filled, Polyolefin Insulated Copper Conductor.

2.2.2 Rural Electrification Administration (REA).

REA BULLETIN	REA Specification for Filled Telephone Cables.

2.2.3 National Electrical Manufacturers Association (NEMA) Specifications.

WC-26 Non-returnable Reels for Wires and Cables

2.3 Precedence of documents. - In the event of a conflict between the above-mentioned documents and this specification, this specification shall govern.

2.4 Document sources. - Copies of this specification may be obtained from the Federal Aviation Administration office issuing the invitation for bids, (IFB).
Requests, addressed " Attention Contracting Officer", should include the specification number, date and revision level, and should state the pertinent contract, IFB, or the intended use of the requested material.

Copies of the above documents may be obtained as follows:

ICEA specifications may be obtained from the Insulated Cable Engineers Association, P. O. Box P, South Yarmouth, MA 02664.

NEMA specifications may be obtained from the National Electrical Manufacturers Association, 2101 L Street, NW, Washington, D.C. 20037.

ISO standards may be obtained from the American National Standards Institute, ANSI, 11 West 42 Street, 13th floor, New York, 10036 NY.

REA specifications may be obtained from the US Department of Agriculture (USDA), Rural Electrification Administration (REA), Washington, and DC 20250-1500.
Publication Office, PDMB, Room 0174-S, AG Box 1533.

3. REQUIREMENTS.

3.1 Materials. - Materials shall be as specified herein. When materials are required but not defined by this specification they shall be consistent with the performance characteristics of the materials, which have been defined. The insulation and jacket materials shall be made from virgin compounds.

3.2 Workmanship. - Cable shall be manufactured and processed consistent with requirements defined in ICEA S-84-608. The cable shall be free of any imperfections, which may affect its serviceability.

3.3 Design and construction. - The finished cable shall be circular in cross section.

3.3.1 Conductors.

3.3.1.1 Size. - Each conductor in the cable shall consist of a solid, round copper wire, AWG #19 or if specified #22 as specified in ICEA S-84-608 paragraph 2.1.

3.3.1.2 Materials. - The conductor material shall be per the requirements of ICEA S-84-608, paragraph 2.1.

3.3.1.3 Conductor joints. - Joints made in conductors during the manufacturing process shall be butt brazed, using a silver alloy and non-acid flux; or butt welded per ICEA S-84-608 paragraph 2.2.

3.3.2 Insulation. - Except as allowed herein, each conductor shall be insulated with either solid polyethylene or solid polypropylene as per ICEA S-84-608 paragraph 3.2.1. Only one type of insulating material shall be used within a cable.

3.3.2.1 Insulating materials. - The insulating materials shall comply with the performance characteristics defined in ICEA S-84-608 paragraphs 3.1.1 through 3.1.3 as appropriate. The insulating materials shall include a thermal oxidative stabilizer as stipulated in ICEA S-84-608 paragraph 3.4.6.

3.3.2.2 Insulation eccentricity. - The eccentricity of the insulation shall not exceed the values in the table included in paragraph 3.3 of ICEA S-84-608.

3.3.2.3 Insulation colors. - The insulation shall be uniformly colored per the table and cited standards included in paragraph 3.3 of ICEA S-84-608.

3.3.2.4 Splices. - Conductors being spliced shall be reinsulated with a non-hygroscopic dielectric material. The reinsulation process shall ensure that the conductor is effectively covered. The insulated splice shall satisfy all applicable requirements of ICEA S-84-608 paragraph 3.3.

3.3.2.5 Insulation physical requirements.

3.3.2.5.1 Adhesion. - The adhesion of the insulation shall be such that the values cited in ICEA S-84-608 paragraph 3.4.1 are not exceeded.

3.3.2.5.2 Elongation. - The extensibility of the insulation shall not be less than the value cited in ICEA S-84-608 paragraph 3.4.2.

3.3.2.5.3 Cold bend. - The cold bend performance of the insulated conductors shall satisfy or exceed the requirements of ICEA S-84-608 paragraph 3.4.4.

3.3.2.5.4 Shrinkback. - The shrinkback of insulated conductors shall not exceed the value cited in ICEA S-84-608 paragraph 3.4.5.

3.3.2.5.5 Thermal oxidation stability performance. - The insulation of the completed cable shall satisfy or exceed the minimum requirements defined in ICEA S-84-608 sub-paragraph B of paragraph 3.4.6.

3.3.3 Cabling.

3.3.3.1 Forming of pairs. - The insulated conductors shall be twisted into pairs. The average length of twist as averaged by any ten-foot (3.05 m) section shall not exceed 6.5 inches (165 mm). Pair twists shall be designed so as to comply with requirements for capacitance unbalance limits stated in ICEA S-84-608 paragraph 8.5.

3.3.3.2 Color-coding. - Each pair in the cable shall be easily distinguishable from every other pair of a 25 pair group by coloring of the conductor insulation. The pair numbers and their associated colors and assembly of groups shall conform to the tables included in ICEA S-84-608, paragraph 3.5.

3.3.3.3 Forming of core of cable. - In cables having 25 pairs or less, the twisted pairs shall be assembled to form a substantially cylindrical core. Fillers, if used, shall be non-hygroscopic and non-wicking.

In cable having more than 25 pairs, the twisted pairs shall be grouped, each group being bound by non-hygroscopic and non-wicking threads or tape. Groups shall not contain more than 25 pairs, except as allowed in paragraph 3.3.3.1. When desired for manufacturing reasons, the basic 25 pair groups may be divided into two or more subgroups. Each subgroup shall have a subgroup binding of the colors for its particular 25 pair count as shown in ICEA S-84-608, paragraph 4.1.2. Alternatively each subgroup binding may have the color types for its 25 pair group imprinted.

Color subgroup-binders or group binders made of threads shall not have less than three threads of each color arranged as color bands. When tapes are used they may be colored or they may be imprinted with the unit number and the types of colors included. The tapes or threads shall be applied with a spacing not to exceed four inches (102 mm).

3.3.4 Core covering. - The core shall be covered with one or more overlapping layers of non-wicking and non-hygroscopic dielectric material of thickness sufficient to assure compliance with requirements cited in ICEA S-84-608 paragraph 4.4. All parts of the core shall be completely covered.

3.3.5 Moisture barrier.

3.3.5.1 Core interstices. - The cable core interstices shall be filled with a moisture blocking substance per paragraph 1.6 and paragraph 4.5 of ICEA S-84-608. The substance shall be one of the types listed in ICEA S-84-608, paragraph 4.5.1. Removal of the substance for terminating or splicing purposes shall only require wiping with a dry cloth. The substance shall fill all interstices of the cable core. The coloring of the substance shall not interfere with identifying the color coding of the pairs. The flow characteristics of the substance shall meet the requirements of paragraph 9.1 of ICEA S-84-608.

3.3.5.2 Jacket-shield interface. - A flooding compound, per the stipulations of ICEA S-84-608 paragraph 4.6 shall be provided.

3.3.6 Shield.

3.3.6.1 Type I cable. - A bare aluminum single tape shield as defined in ICEA S-84-608 paragraph 6.2.1 shall be applied as specified in ICEA S-84-608 paragraph 6.3 over the core wrap of Type I cable.

3.3.6.2 Type II cable. - The shield/armor defined herein for Type II cable shall be corrugated copper clad stainless steel tape as defined in ICEA S-84-608 paragraph 6.2.5
It shall be applied in accordance with ICEA S-84-608 paragraph 6.3.

3.3.6.3 Shield extensibility. - The extensibility of the corrugated shield shall not be less than the values cited in ICEA S-84-608 paragraph 6.4

3.3.6.4 Shield continuity/conductivity. - The shield shall be electrically continuous throughout the cable as per ICEA S-84-608 paragraph 6.2.4.1.

3.3.7 Electrical.

3.3.7.1 Resistance. - Conductor DC resistance and resistance unbalance values shall not exceed the values cited in ICEA S-84-608 paragraphs 8.1 and 8.2.

3.3.7.2 Capacitance. - Mutual, differential, pair to pair, pair to ground and screened values shall not exceed the values cited in ICEA S-84-608 paragraphs 8.3 through 8.6 and 8.10.

3.3.7.3 Attenuation. - The average attenuation of all pairs of a completed cable shall not exceed the values cited in ICEA S-84-608 paragraph 8.7.

3.3.7.4 Unit crosstalk. - The crosstalk for both near end (NEXT) and far end (FEXT) shall not exceed the values cited in ICEA S-84-608 paragraphs 8.8 and 8.8.1. Crosstalk for screened, i.e., between-compartment cables shall not exceed the values cited in ICEA S-84-608 paragraph 8.9.

3.3.8 Jacket inner and outer. - The inner and outer jackets shall be in accordance with the citations and stipulations in ICEA S-84-608 section 7.

3.3.8.1 General. - A polyethylene jacket shall be applied over the shield and shall be free of imperfections and as smooth as is consistent with high grade cable manufacturing practices.

3.3.8.2 Jacket integrity. - Opening of the cable jacket for repair or for any other purposes shall not be permitted. In accordance with REA PE-39, minor jacket defects not in excess of 0.125 inch (3 mm) in size in any direction may have been repaired by having heat fused jacket grade repair-compound with the cable jacket.

3.3.8.3 Jacket materials. - The jacket shall be polyethylene conforming to ICEA S-84-608, paragraph 7.2.1 and shall contain carbon black anti-oxidant in sufficient quantities to insure proper aging characteristics.

3.3.8.4 Jacket thickness. - Jacket thickness shall be in accordance with the following for both Type I and Type II cables as cited in ICEA S-84-608 paragraph 7.1.2 (inner) and 7.2.2 (outer). The minimum average thickness of the jacket shall be as cited in ICEA S-84-608 paragraph 7.2.2.

3.3.9 Cable identification. - The outer jacket of all cable shall be permanently marked at intervals not exceeding 5 feet (1.52 meters) with a durable, contrasting color to identify the manufacturer, year of manufacture, type of cable (including the word "filled" to indicate compound filled).

4. QUALITY ASSURANCE PROVISIONS.

4.1 Quality control program. - The contractor shall maintain a quality control program in accordance with ISO 9003 AND ISO 10012-1. The contractor shall have a copy of a current qualification test report for a cable of equal or similar construction showing compliance with this specification. All cables to be procured, but not yet manufactured, shall be tested at the factory at the time of manufacture. The FAA shall have the option to have these tests witnessed by a government representative. The contractor shall furnish certified test reports and the manufacturer's current Qualification Test Report (QTR). Any reel of cable offered for inspection but failing to meet the requirements of the tests for the inspection shall not be offered for retest without the approval of the Contracting Officer.

4.2 Tests to be performed on all completed cables. - All cables to be manufactured in response to an IFB shall be tested at the factory for the parameters specified in the ensuing paragraphs and certified test results shall be submitted to the Government.

4.2.1 Continuity. - The continuity of all conductive cable elements shall be tested in accordance with the citations and stipulations of ICEA S-84-608 paragraph 8.16.

4.2.2 Dielectric strength.

4.2.2.1 Conductor-to-conductor. - The dielectric strength between the core conductors shall be tested to insure freedom from shorts and cross circuits in each length of completed cable in accordance with the citations and stipulations of ICEA S-84-608 paragraph 8.12 in the solid column.

4.2.2.2 Conductor-to-screen. - The dielectric strength between the core conductors and the screen tape shall be tested to determine freedom from grounds in accordance with the citations and stipulations of ICEA S-84-608 paragraph 8.14. In the screened cable the screen tape shall be left floating.

4.2.2.3 Conductor-to-shield. - The dielectric strength between the core conductors and the shield shall be in accordance with the citations and stipulations of ICEA S-84-608, paragraph 8.13, in the single jacketed, solid column.

4.2.3 Mutual capacitance. - The average mutual capacitance shall be measured on all cables. If the average mutual capacitance for the first 100 pairs tested from randomly selected groups is between 50 and 53 nF/km (80 and 85 nF/mile), in accordance with ICEA S-84-608 paragraph 8.3, the remainder of the pairs need not be tested on the 100 percent basis.

4.2.4 Jacket integrity. - The cable shall be spark tested between the shield and an external electrode to determine that the jacket is free of holes. A voltage of 15,000 dc or 10,000 ac shall be used. All repairable faults (see paragraph 3.3.8.2) shall be tested after repair.

4.3 Qualification tests. - The contractor shall provide, when stipulated by the Government, summary records of qualification test results for the cable attributes cited in section 3; or if stipulated in the invitation for bids (IFB) referee samples per the following.

4.3.1 Samples. - Qualification test-sample selection and preparation shall be in accordance with sampling methods and practices cited in REA PE-39, Appendix A, paragraph 2, Qualifications Test Methods Bulletin.

4.3.2 Referee samples. - When so stated in the invitation for bids IFB or when later requested by the Contracting Officer, samples of the completed cable shall be supplied to a testing laboratory selected by the Contracting Officer. Where the shipment of samples for inspection or referee tests is required, such shipment will be at Government expense on a Government bill of lading. Packing of samples and delivery to common carrier will be at the expense of the contractor.

5. PREPARATION FOR DELIVERY.

5.1 General. - Cable shall be delivered wound on reels conforming to paragraph 5.2.

5.1.1 Cable length per reel. - Unless otherwise indicated, each reel shall contain one continuous length of cable with a tolerance of plus 5 minus zero percent per reel as follows:

National Stock Number	Type	Description	Length Per Reel

5.2 Reel construction.

(a) Cable reels shall be new and non-returnable, and shall comply with the requirements of NEMA specification WC-26 (Wire and Cable Packaging). Drum diameter shall be a minimum of 24 inches. Plywood reels are not acceptable.

(b) The reels shall be designed for storage outside in unprotected areas, and shall include provisions for rainwater/moisture drainage when the reels are stored both on end and on side. A layer of reflector material such as water-resistant paper, plastic, aluminum foil etc shall be applied over the entire outer layer of cable on the reel.

(c) Capacity of reels shall be sufficient to allow a spacing of a minimum of two cable diameters between the top layer and the lagging specified in paragraph 5.2 (e).

(d) Where the size of the reels required exceeds the maximum size listed in NEMA WC-26, new reels of equal construction to that corresponding to the requirements of NEMA WC-26 shall be used. Ends of cable shall be sealed to exclude moisture. Flange cable entry slots and cable ends shall be covered with a minimum of 18-gauge sheet metal. Where the gross weight exceeds 2500 pounds, metal reels shall be provided.

(e) The reels shall be lagged with nominal 2-inch by 4-inch no. 2 common lumber. Lagging shall be edge-to-edge around the reel circumference and shall be strapped with two or more steel straps over the lagging.

5.3 Reel marking. - The reel shall be marked with the following information, permanently applied on the flange with ink or paint:

(a) "manufactured in accordance with FAA-E-2072c Type ___"

(b) conductor size, type, and number.

(c) "armored or unarmored"

(d) year of manufacture

(e) length of cable

(f) contractor's name

(g) contract number, under which the cable was purchased

(h) National Stock Number (NSN) (if provided)

(i) name and address of consignee

6. NOTES. - The subparagraphs below are only for the information of the Contracting Officer (CO). They are intended to assist the CO in formulating a contract. They are not contract requirements, nor binding on either the Government or the contractor, except to the extent that they may be specified elsewhere in the contract as such. The contractor shall not rely on the information in these subparagraphs.

6.1 Items requiring specification in the Invitation For Bids (IFB).

6.1.1 Number and size of conductors. - The IFB must indicate the number of conductors and the size of conductors and classification per paragraph 1.2.

6.1.2 Cable length per reel. - The IFB must include the cable length per reel. The suggested wording for variance in quantity is the following:

"Cable shall be supplied on non-returnable reels in continuous lengths of
(See paragraph 5.1) XXXX feet plus 5 minus zero percent per reel containing no splices"

6.1.3 Cable pairs. - Procurement provisions should include the number of pairs required per cable.

6.2 Testing.

6.2.1 Factory inspection option. - The IFB shall state that the Government shall have the option of witnessing production tests conducted at the factory (see paragraph 4.1). Regardless of whether the government witnesses the production tests, the contractor shall furnish certified test reports and the manufacturer’s most recent Qualification Test Report as specified in 4.1.

6.2.2 Referee samples. - The IFB must indicate if and subject to what conditions, referee samples for independent qualification testing will be required.

* * * * * *

Item MDOT-110 Mobilization

110.01 DESCRIPTION

This work consists of preparatory work and operations including, but not limited to, the following:

A. The movement of personnel, equipment, supplies, and incidentals to the project site;

B. The establishment of the Contractor's offices, buildings, and other facilities to support work on the project including associated job site posters;

C. Other work and operations the Contractor must perform;

D. Expenses incurred before beginning work on pay items at the project site; and

E. Pre-construction costs, exclusive of bidding costs, that are necessary direct costs to the project rather than directly attributable to other pay items under the contract. This work consists of removing miscellaneous structures and materials to clear the right-of-way, salvaging or disposing of removed materials and backfilling the resulting excavated sites.

110.02 MATERIALS

None Specified.

110.03 CONSTRUCTION

All jobsite posters and employment notices required by state and federal regulations and the contract are to be posted in a conspicuous place. Posting of jobsite posters and employment notices (posted display, foreman vehicle binder, etc.) for short-term or mobile operations will be as approved by the Engineer.

110.04 MEASUREMENT & PAYMENT

A. The Department will specify the maximum bid percentage for Mobilization, Max (percentage) in the proposal. If the Contractor submits a bid amount for Mobilization, Max (percentage) that exceeds the maximum bid amount, the Department will use the maximum bid amount as the Contractor's lump sum bid amount and will correct the total bid amount to reflect this maximum bid amount.

The Department will pay the Contractor for Mobilization, Max (percentage) in accordance with Table 110-1. The percent of the original contract amount earned does not include the Mobilization, Max (percentage) pay item.

Table 110-1: Partial Payment Schedule for Mobilization

Percent of Original Contract Amount Earned	Percent of Bid Amount for Mobilization, Max (dollar)
5%	50%
10%	75%
25%	100%

The first scheduled payment for Mobilization, Max (percentage) will not occur until the Engineer has verified and documented the posting of required jobsite posters and employment notices.

When the percentage of the original contract amount earned is less than 5% on the partial payment schedule, the Department will pay the Contractor for costs of project-specific bonding, insurances, and permits when proof of payment is received and accepted by the Engineer. The Engineer will then subtract these costs from the bid amount for Mobilization, Max (percentage).

The total sum of all payments for this item will not exceed the bid amount for Mobilization, Max (percentage), regardless of the following conditions:

1. The Contractor shut down the work on the project for any reason;
2. The Contractor moved equipment away from the project and then back again; or
3. The Department added additional quantities or items of work to the contract.

If the contract does not contain a Mobilization, Max (percentage) pay item, the unit prices for other items of work will include the costs of mobilization.

B. If at any time during the project, the Engineer documents that the required jobsite posters and employment notices are not posted appropriately, the Engineer will provide documented instructions to the Contractor that corrective action is required. Upon receipt of the notification of corrective action, the Contractor has 72 hours to correct the deficiency. If the issue cannot be corrected within the 72-hour period, the Contractor will develop a documented implementation schedule for the corrective action and submit the schedule to the Engineer for approval within 72 hours of receiving the original documented notification. If the schedule is not approved, or if the schedule is approved but is not followed, the following actions will occur:

   1. The Engineer may stop work on the project until the Contractor completes corrective action; and
   2. The Engineer will process a contract price adjustment in the amount of $1,000 per calendar day or portion thereof that the corrective action remains incomplete or the implementation schedule is not followed. The contract price adjustment will continue to be assessed until jobsite posters and employment notices are posted appropriately, the Engineer has been notified of the corrective action, and the Engineer has verified the correction.

110.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-110.05.01	Mobilization (Max 10%)	Lump Sum (LS)
MDOT-110.05.02	Mobilization (Max 10%) – Bid Alt 1	Lump Sum (LS)

END OF ITEM MDOT-110

Item MDOT-201 Clearing

201.01 DESCRIPTION

This work consists of clearing, selectively thinning, clearing for fence, and applying growth preventive material if required.

201.02 MATERIALS

Provide materials in accordance with the following section:

1. Growth Preventive Material..... 917

The MDARD must certify the applicator that is used to apply growth preventive material. Provide certification to the Engineer prior to the application.

201.03 CONSTRUCTION

A. **Clearing.** Cut, remove, and dispose of trees, stumps, brush, shrubs, roots, logs, and other vegetation. Salvage marketable timber. Preserve vegetation and objects that are required to remain from injury or defacement.

1. **Removals.** Remove trees, stumps, and other vegetation to 10 feet outside the slope stake line or to the right-of-way line, whichever is less. In other areas, remove trees, stumps, and other vegetation as shown on the plans. Remove trees without endangering traffic and the general public, injuring other trees, and damaging structures or property.

   In peat treatment areas, remove trees, stumps, and other vegetation to the outer limits of the peat excavation. Between outer peat excavation limits and outer clearing limits, cut off vegetation to no greater than 6 inches above the ground. Removal of stumps and roots beyond the peat excavation limits is not required. If the Engineer approves, bury stumps with at least 2 feet of cover in peat disposal areas outside the limits of sound fill.

2. **Protecting Plant Life.** Protect vegetation that is not designated for removal on the plans or by the Engineer. Repair or replace trees or shrubs damaged by Contractor operations at no additional cost to the Department.

3. **Salvaging Marketable Timber.** Do not burn or waste marketable timber. Marketable timber includes trees with a diameter of at least 6 inches measured 4½ feet above the base of the tree at the ground line. Timber does not need to be cut in lengths of less than 8 feet.

   Salvage marketable timber in accordance with the following:

   a. Right-of-Way Purchased in Fee Simple. On right-of-way purchased in fee simple, the Department considers marketable timber the property of the Contractor. Make marketable timber available to wood-using industries or individuals.

   b. Right-of-Way Easements. On right-of-way easements, the Department considers marketable timber the property of the landowner. Cut and neatly stack marketable timber on the landowner’s property adjacent to the right-of-way.

Provide the Engineer with the property owner's written direction for the disposal of the marketable timber. Take ownership of marketable timber not wanted by the property owner and make available to wood-using industries or individuals.

On easements or special use permits on land owned by the Forest Service or MDNR, marketable timber is the property of the Forest Service or MDNR. Cut and dispose of this timber as agreed by the Department and the Forest Service or MDNR. The Forest Service or MDNR may sell or otherwise dispose of standing marketable timber to others if its removal does not unduly interfere with Contractor operations.

4. **Disposing of Unsalvageable Material.** Do not dispose of material, temporarily or permanently, in wetlands or floodplains. Dispose of unmarketable timber and vegetative debris resulting from clearing and selective thinning in accordance with subsection 205.03.P and using one of the following methods:

   a. Chipping. Dispose of chips outside the right-of-way unless otherwise approved by the Engineer.

   b. Burning. No burning shall be performed on the airfield.

B. **Selective Thinning.** Not Used.

C. **Clearing for Fence.** Not Used.

201.04 MEASUREMENT & PAYMENT

A. **Clearing.** The Engineer will measure Clearing by horizontal area bounded by the outermost trees cut. The Engineer will establish the perimeter line along the outside faces of the trunks.

The cost of clearing areas up to 10 feet outside the limits of earth disturbance, state-provided borrow areas, clear vision areas, or other areas designated on the plans is included in the unit price for related pay items unless clearing is a separate pay item.

If the engineer directs clearing not shown on the plans beyond 10 feet outside the limits of earth disturbance in non-state-provided borrow areas, or in clear vision areas, and the contract provides no separate pay item for clearing, the department will pay for this clearing as extra work.

If the Engineer directs the Contractor to return to perform additional clearing of areas less than ½ acre after the Engineer accepted the clearing of an area, the Department will pay for this clearing as extra work.

B. **Thinning, Selective.** Not Used.

C. **Clearing, Fence.** Not Used.

201.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-201.05.01	Clearing	Acre (AC)
MDOT-201.05.02	Clearing - Bid Alt 1	Acre (AC)

END OF ITEM MDOT-201

Item MDOT-202 Removing Trees, Stumps, and Corduroy

202.01 DESCRIPTION

THIS WORK CONSISTS OF REMOVING TREES AND STUMPS WITH A DIAMETER OF AT LEAST 6 INCHES LOCATED OUTSIDE THE CLEARING LIMITS AND REMOVING CORDUROY WITHIN THE LIMITS OF THE PROPOSED ROADBED AND BACKFILLING AS REQUIRED.

202.02 MATERIALS

Provide materials in accordance with the following:

1. Sound Earth..... 205
2. Granular Material Class III..... 902

202.03 CONSTRUCTION

A. **Removing trees or stumps**. Remove and dispose of trees or stumps with a diameter of at least 6 inches that are outside the clearing limits. Remove non-ornamental fruit trees within the right-of-way even if not shown on the plans. Remove and dispose of trees, stumps, roots, and debris in accordance with Section 201.

If removing a stump could result in damage to existing utilities, remove the stump by chipping it to a depth of at least 12 inches below the finished ground surface. Remove other stumps by chipping only if approved by the Engineer. Backfill removal areas with granular material Class III within the influence of the subgrade surface and sound earth outside the influence of the subgrade surface.

B. **Removing corduroy.** Not Used.

202.04 MEASUREMENT & PAYMENT

A. **Trees and Stumps**. The Engineer will determine the size of trees by the diameter of the trunk measured to the nearest full inch 4½ feet above the ground line at the base of the tree. The Engineer will measure trees with major limbs lower than 4½ feet from the ground at the smallest diameter below the limbs.

The cost of removing trees or stumps with a diameter of less than 6 inches is included in other pay items.

Where more than one trunk has grown from a common stump, the Engineer will measure each trunk as a separate tree.

The Engineer will measure stump diameters to the nearest full inch at the top of the stump.

For stumps incorrectly shown on the plans as trees designated for removal, the Engineer will measure, and the Department will pay for, removing stumps with the relevant stump removal pay item. If the contract does not include stump removal pay items but includes tree removal pay items, the Department will pay for removing stumps with the relevant tree removal pay item.

The unit price for tree and stump removal pay items includes the cost of providing and placing backfill. Tree removal pay items include respective stump removal.

B. **CORDUROY, REMOVAL.** Not Used.

202.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-202.05.01	Tree, Rem, 6 in to 18 in	Each (EA)

END OF ITEM MDOT-202

Item MDOT-203 Removing Drainage Structures, Culverts, and Sewers

203.01 DESCRIPTION

This work consists of removing or abandoning, in whole or in part, drainage structures, culverts, and sewers; salvaging, storing, and disposing of removed materials; and backfilling and compacting the excavated sites.

203.02 MATERIALS

Provide materials in accordance with the following sections:

1. Sound Earth..... 205
2. Granular Material Class III..... 902

203.03 CONSTRUCTION

A. **Drainage Structures.** When removing or abandoning a drainage structure, rebuild and reconnect live sewers through the removal area. Maintain service of live sewers during construction operations.

If the plans show abandoning a drainage structure, remove the cover and break down the masonry in accordance with subsection 204.03. Dispose of materials in accordance with subsection 205.03.P and backfill in accordance with subsection 204.03.C.

B. **Culvert Pipe.** Completely remove pipe culverts as required, including end treatments.

Dispose of materials in accordance with subsection 205.03.P and backfill in accordance with subsection 204.03.C.

Remove only the portions of the existing culvert pipe necessary to allow connection to the new work when extending an existing culvert or replacing the existing end treatment. Do not damage the remaining culvert pipe.

Bulkhead abandoned culvert pipes in accordance with subsection 402.03.E or use other Department-approved methods. If the Engineer determines that the culvert is not in suitable condition for abandonment, the Engineer will specify alternate treatment.

For culvert pipes with a top elevation within 5 feet of the top of pavement and that require abandonment, review the abandonment treatment with the Engineer.

C. **Sewer Pipe.** Remove sewers (storm, sanitary, or combined) or parts of sewers that require removal or that interfere with the new construction.

Dispose of materials in accordance with subsection 205.03.P and backfill in accordance with subsection 204.03.C.

Remove only the part of the existing sewer necessary to allow the required connection to the new work when extending existing sewers or incorporating existing sewers into the new work. Trim the connecting sewer pipe edges to meet the required lines and grades without weakening or damaging those parts of the remaining sewer.

Bulkhead abandoned sewers in accordance with subsection 402.03.E or use other Department-approved methods. If the Engineer determines that the sewer pipe is not in suitable condition for abandonment, the Engineer will specify alternate treatment.

For sewer pipes with a top elevation within 5 feet of the top of pavement and that require abandonment, review the abandonment treatment with the Engineer.

203.04 MEASUREMENT & PAYMENT

A. **General.** Unless otherwise required, the Engineer will measure structures or materials in the original positions.

The unit prices for the removal pay items include the cost of breaking down structures and material; sawing, removal, and disposal; providing, placing, and compacting backfill; and providing and placing replacement soil or base material.

The Department will pay for piling or timber cribs encountered during structure removal, but not shown on the plans, as extra work.

B. **Drainage Structure, Removal and Drainage Structure, Abandon.** The unit prices for **Dr Structure, Rem**, and **Dr Structure, Abandon** include the cost of maintaining and reconnecting live sewers and of removing attached parts and connections.

C. **Culvert, Removal and Culvert End, Removal**. The engineer will measure elliptical or pipe arch culverts across the greatest dimension. The cost of removing existing end treatments, regardless of type, is included in the unit prices for the related culvert removal or culvert end removal pay items.

D. **Removal of pipes (culverts, sewers, underdrains, etc.) with diameters less than 12 inches.** The cost of removing pipes, including culverts, sewers, and underdrains, with diameters less than 12 inches is included in the unit price for constructing the new structure, culvert, or sewer if portions of the existing pipe are within the excavation limits of a new structure, culvert, or sewer.

E. **Abandoning Pipe Culverts and Abandoning Sewers.** The department will not pay separately for abandoning pipe culverts and abandoning sewers. Unless included in the unit price for abandoning drainage structures, the Department will pay for bulkheads greater than 12 inches that are required in abandoning pipe culverts and abandoning sewers as **Sewer Bulkhead** of the type required, in accordance with subsection 402.04.d.

F. **Removal of End Treatments.** The Department will pay for removing end treatments on existing sewers as **Culv End, Rem.**

203.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-203.05.01	Dr Structure, Rem	Each (EA)
MDOT-203.05.02	Dr Structure, Rem (Underdrain Cleanout)	Each (EA)
MDOT-203.05.03	Sewer, Rem, Less than 24 inch	Linear Foot (LF)
MDOT-203.05.04	Sewer, Rem, Less than 24 inch (Underdrain)	Linear Foot (LF)
MDOT-203.05.05	Dr Structure, Rem - Bid Alt 1	Each (EA)
MDOT-203.05.06	Dr Structure, Rem (Underdrain Cleanout) - Bid Alt 1	Each (EA)
MDOT-203.05.07	Sewer, Rem, Less than 24 inch - Bid Alt 1	Linear Foot (LF)
MDOT-203.05.08	Sewer, Rem, Less than 24 inch (Underdrain) - Bid Alt 1	Linear Foot (LF)

END OF ITEM MDOT-203

Item MDOT-204 Removing Miscellaneous Structures and Materials

204.01 DESCRIPTION

This work consists of removing miscellaneous structures and materials to clear the right-of-way, salvaging or disposing of removed materials and backfilling the resulting excavated sites.

204.02 MATERIALS

Provide materials in accordance with the following:

1. Sound Earth 205
2. Granular Material Class III 902

204.03 CONSTRUCTION

A. **Breaking Down and Removing.** Remove structures or portions of structures entirely or to the limits required, including attached parts and connections. Do not damage the remaining portion of an existing structure.

1. **Partial Removal.** Not Used.
2. **Pavement.** Remove pavement and similar structures to an existing joint or to a sawed joint. Saw concrete full depth unless otherwise approved by the Engineer. Provide for proper grades and connections to new work.

   All anticipated pavement removal operations conducted over utilities and other critical areas identified on the plans must be saw cut and the pavement removed full depth in such a manner as to not disrupt or damage these utilities or critical areas. Impact- or vibratory-type equipment is not permitted.

   Replace adjacent soils or base materials removed with concrete removal operations with similar material approved by the Engineer.
3. **Masonry and Concrete Structures.** Remove entirely or break down walls, foundations, and similar structures, excluding bridges, culverts, and retaining walls, in accordance with subsection 204.03.A.1.
4. **Basement Cleanout.** Not Used.
5. **Structures and Retaining Walls.** During the removal operations, protect the remaining portions of existing structures and new work under construction from damage.

   Do not use explosives unless the Engineer provides written permission in accordance with subsection 107.17. The Engineer's written permission does not relieve the Contractor of liability or responsibility for damages resulting from the use of explosives.
6. **Culvert Structures.** Remove culvert structures or parts of culvert structures required for removal or that interfere with the new construction.

For contracts requiring extension or incorporation of existing culvert structures into the new work, remove only enough of the existing structure to allow a connection to the new work. Trim the connecting edges of the existing culvert structure to the lines and grades as required without weakening or damaging that part of the structure.

7. **Railway Track Work.** Not Used.

8. **Guardrail.** Not Used.

9. **Utility Pole.** Remove poles, parts, and connections attached to utility poles.

10. **Fence.** Not Used.

11. **Concrete Barrier and Glare Screen.** Not Used.

B. **Disposal of Materials.** Assume ownership of removed materials. Without causing damage, remove materials salvaged for use by the Department, local agency, or others and store outside the construction limits in a location and manner approved by the Engineer. Dispose of materials not incorporated into the new work in accordance with subsection 205.03.P before the Department accepts the project.

The Contractor may salvage materials that meet specification requirements and use them in the new work.

Dispose of broken concrete, matted together by steel reinforcement, outside the right-of-way. Provide the Engineer with written permission from the property owner of the disposal site.

C. **Backfilling.** Backfill excavated sites or holes resulting from removals within the influence of the subgrade surface limit per direction within the Contract Documents or with granular material Class III as submitted and approved by the Engineer. Place and compact the granular material in accordance with the controlled density method in subsection 205.03.H.4.a.

For excavated sites outside the influence of the subgrade surface, backfill with sound earth in accordance with subsection 205.03.H.4.a and submitted and approved by the Engineer.

204.04 MEASUREMENT & PAYMENT

A. **General.** Unless otherwise required by the contract, the Engineer will measure the structure or material quantities in their original position. The cost of breaking down and removing, sawing, saw-cutting, disposing of materials, and providing, placing, and compacting backfill is included in the unit price for the related pay items. The cost of providing and placing replacement soils or base materials is included in the related pay items. The Department will pay for piling or timber cribs encountered during the removal of structures, but not shown on the plans, as extra work.

B. **Pavement, Removal.** The limits of Pavt, Rem, as shown on the plans, will be established at the discretion of the Engineer. The Engineer may decide to leave areas in place or remove additional sections to attain the required cross section and base. The Engineer will measure Pavt, Rem in accordance with the following criteria:

1. **HMA Pavements and HMA Driveways.** The Department will pay separately for the removal of curb, curb and gutter, or gutter in conjunction with removing hot mix asphalt (HMA) pavements or HMA driveways.
2. **HMA No Greater Than 12 Inches Thick.** The Engineer will measure the removal of HMA surface no greater than 12 inches thick together with any underlying material designated for removal to a depth as specified in 204.05.
3. **HMA Greater Than 12 Inches Thick.** The Engineer will measure the removal of HMA surface, greater than 12 inches thick together with any underlying material designated for removal to a depth as specified in 204.05.
4. **Concrete and Masonry Pavements and Concrete Driveways.** The Engineer will measure the removal of concrete pavements or gravel, together with any underlying materials designated for removal to a depth as specified in 204.05.
5. **Curb, Removal; Gutter, Removal; or Curb and Gutter, Removal.** Not Used.
6. **Sidewalk, Removal.** Not Used.
7. **Basement Cleanout.** Not Used.
8. **Track Removal.** Not Used.
9. **Utility Pole Removal.** The unit price for Utility Pole, Rem includes the cost of removing and disposing of the pole, attached parts, and connections.
10. **Structures, Removal and Structures, Removal, Portions.** The lump sum unit prices for Structures, Rem shall include the following costs:
    a. Prepare and execute a Fugitive Dust Plan in compliance with the City of Detroit's Air Quality Ordinance and BSEED requirements found here: https://detroitmi.gov/departments/buildings-safety-engineering-and-environmental-department/bseed-divisions/environmental-affairs/air-quality-ordinances

       Dust monitoring must be performed throughout the entire structure removal duration and must be done by continuous direct read monitoring units with data logging capability.

    b. Prepare and execute required remediation and abatement practices recommended by the Pre-Demolition Hazardous/ Regulated Material Report within the Contract Documents.

    c. Remove and dispose of structures and their foundations in their entirety off site. All materials deemed hazardous must be containerized appropriately and taken to the proper landfill. A waste manifest for these materials shall be supplied to both the DBRA and the ENGINEER.
11. **Payment for Culvert, Other than Pipe, Removal.** The unit price for Culv, Other than Pipe, Rem includes the cost of breaking down, removing, sawing, and disposing of materials and of providing, placing, and compacting backfill.

12. **Payment for Masonry and Concrete Structures, Removal.** The Department will pay only for Masonry and Conc Structure, Rem if the smallest dimension of the masonry or concrete structures, or parts of masonry or concrete structures, is at least 12 inches, and the smallest dimension of reinforced concrete structures is at least 8 inches. The Department will pay for the removal of other masonry and concrete structures as Excavation, Earth in accordance with subsection 205.04.
13. **Guardrail, Removal.** Not Used.
14. **Fence, Removal.** Not Used.
15. **Concrete Barrier, Removal.** Not Used.
16. **Glare Screen, Removal.** Not Used.
17. **Bulkheads.** The cost of bulkheading abandoned pipes, conduits, or service connections with a diameter no greater than 12 inches and encountered in excavation is included in other related pay items. The Engineer will measure bulkheading abandoned pipes, conduits, or service connections with a diameter greater than 12 inches as Sewer Bulkhead in accordance with subsection 402.03.E.

204.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-204.05.01	Pavt, Rem, 6" Milling Over 6-8" Crushed Aggregate	Square Yard (SY)
MDOT-204.05.02	Pavt, Rem, 3-4" ACC Pavement Over 8-24" Crushed Aggregate	Square Yard (SY)
MDOT-204.05.03	Pavt, Rem, 6"-8" ACC Pavement Over 8" Crushed Aggregate	Square Yard (SY)
MDOT-204.05.04	Pavt, Rem, 10" ACC Over 1-9" Crushed Aggregate Over 1" ACC Over 9" PCC	Square Yard (SY)
MDOT-204.05.05	Pavt, Rem, 10" PCC Over 8" Crushed Aggregate	Square Yard (SY)
MDOT-204.05.06	Pavt, Rem, 15" ACC Over 6" Large Aggregate ACC	Square Yard (SY)
MDOT-204.05.07	Pavt, Rem, 10-13" ACC Over 10" Large Aggregate ACC Over 6" PCC	Square Yard (SY)
MDOT-204.05.08	Pavt, Rem, Gravel Removal - Bid Alt 1	Square Yard (SY)
MDOT-204.05.09	Structures, Rem (Hangar & Foundation)	Lump Sum (LS)
MDOT-204.05.10	Structures, Rem (Trailer & Foundation)	Lump Sum (LS)
MDOT-204.05.11	Bollards, Rem	Each (EA)
MDOT-204.05.12	Placement of Millings	Cubic Yards (CY)

MDOT-204.05.13	Utility Pole, Salv (Airfield Pole Salv, Security Camera Salv, Foundation Removed) - Bid Alt 1	Each (EA)
MDOT-204.05.14	Utility Pole, Rem (Light Pole & Foundation)	Each (EA)
MDOT-204.05.15	Electrical Structure, Rem	Each (EA)
MDOT-204.05.16	Guidance Sign Foundation, Rem	Each (EA)
MDOT-204.05.17	Pavt, Rem, 3-4" ACC Pavement Over 8-24" Crushed Aggregate - Bid Alt 1	Square Yard (SY)
MDOT-204.05.18	Pavt, Rem, 6"-8" ACC Pavement Over 8" Crushed Aggregate - Bid Alt 1	Square Yard (SY)
MDOT-204.05.19	Pavt, Rem, 10" ACC Over 1-9" Crushed Aggregate Over 1" ACC Over 9" PCC - Bid Alt 1	Square Yard (SY)
MDOT-204.05.20	Pavt, Rem, 10" PCC Over 8" Crushed Aggregate - Bid Alt 1	Square Yard (SY)
MDOT-204.05.21	Pavt, Rem, Gravel Removal - Bid Alt 1	Square Yard (SY)
MDOT-204.05.22	Pavt, Rem, 18" ACC Pavement Over 6-24" Crushed Aggregate - Bid Alt 1	Square Yard (SY)
MDOT-204.05.22	Placement of Millings - Bid Alt 1	Cubic Yards (CY)
MDOT-204.05.23	Guidance Sign Foundation, Rem - Bid Alt 1	Each (EA)

END OF ITEM MDOT-204

Item MDOT-205 Roadway Earthwork

205.01 DESCRIPTION

This work consists of the following:

A. Constructing earth grades by excavating soil or rock and placing embankments or fills;

B. Salvaging and stockpiling selected materials;

C. Providing, placing, and compacting embankment materials;

D. Trimming the earth grade;

E. Disposing of surplus or unsuitable material; and

F. Maintaining the work in a finished condition until accepted by the Engineer.

Earth excavation consists of the work to excavate materials not otherwise addressed in the contract as separate work items. Rock excavation and subgrade undercutting are separate work items.

Investigate local conditions before bidding in accordance with subsection 102.04. Boring logs shown on the plans are for information only. Refer to MDOT's Geotechnical Manual for detailed data on soils.

G. Definitions

CIP. When used with an embankment item, CIP denotes compacted-in-place.

Frost heave textured material. Material with more than 50% silt particles by weight and a plasticity index of less than 10.

Loose measure (LM). Refer to section 109.01.B.2.

Silt. Material with a particle size from 0.002 mm to 0.075 mm.

Sound Earth. Natural homogeneous material composed of soil or aggregate that can be compacted to the required density, contains no visible organic material, and has a maximum unit weight of at least 95 pounds per cubic foot.

205.02 MATERIALS

Provide materials in accordance with the following sections:

1. Granular Material Class III..... 902
2. Open Graded Aggregate…..... 902
3. Geosynthetics……..... 910

Do not use foundry sand from metal casting for roadway earthwork.

Refer to MDOT's Density Testing and Inspection Manual for maximum unit weight and in-place density test methods.

205.03 CONSTRUCTION

Before beginning earth-disturbing activities, install soil erosion and sedimentation control measures in accordance with Section 208.

The department considers buried rubbish and trash not identified in the Contract a differing site condition in accordance with subsection 103.02.c. All buried rubbish and trash that are found must be disposed of properly.

A. **Preparing Roadway Foundation.** Not Used.

B. **Rock Excavation.** Not Used.

C. **Peat Excavation.** Not Used.

D. **Swamp Backfill.** Not Used.

E. **Subgrade Undercutting.** Not Used.

F. **Subgrade Manipulation.** Scarify, mix, and blend the roadbed subgrade to a depth of 12 inches below the top of subgrade. Compact to at least 95% of its maximum unit weight.

G. **Earth Excavation.** Excavated material is the property of the Contractor.

Compact the subgrade to at least 95% of its maximum unit weight and to a depth of at least 10 inches. If the subgrade cannot be compacted to 95% of its maximum unit weight using conventional construction methods, the Engineer may authorize the use of other methods to attain compaction.

In cut sections where the existing material appears to meet the requirements of subsection 301.02, excavate the grade to top of subbase rather than to the bottom of subbase. The Engineer will then determine whether the existing material meets subbase requirements. Shape material meeting subbase requirements to the top of subbase grade and compact to at least 95% of its maximum unit weight and to a depth of at least 12 inches. The Engineer will adjust earthwork quantities accordingly. Excavate material not meeting subbase requirements to the bottom of subbase. The Department will not consider claims for damage caused by the Contractor’s halting of grading operations so the Engineer can make subbase determinations.

Maintain the roadbed and ditches and provide drainage at all times. Install and remove temporary drainage facilities at no additional cost to the Department.

Perform grading to avoid removing or loosening material outside the required slopes. Replace and compact material removed or loosened outside the slopes to the required density and cross section.

Dispose of surplus or waste material resulting from ditch construction in accordance with subsection 205.03.P. Remove roots, stumps, or other materials that are unacceptable to the Engineer in the slopes and bottom of the ditch and backfill the holes with suitable material. Maintain ditches until the Engineer’s final acceptance.

H. **Roadway Embankment.** Not Used.

I. **Structure Embankment.**

1. **Compaction of Original Ground.** In fill areas on which a structure is required, remove the topsoil from the area within the toes of slope in accordance with subsection 205.03.A.1. Compact the area to at least 95% of the maximum unit weight and at least 9 inches deep.

2. **Placing Structure Embankment.** Place and compact structure embankment to the limits shown on the plans before casting overlying footings. Protect structure embankments from freezing until placement of overlying footings.

    a. **Under Structure Footings Supported by Piling.** Construct structure embankment with granular material Class III within the limits shown on the plans. The Engineer may allow the use of sound earth as an alternate material when placed between April 1 and November 15. Use sound earth as defined in subsection 205.01 except that for rocks, the greatest dimension must be less than 3 inches. Deposit and compact structure embankment in accordance with the controlled density method.

    b. **Under Structure Footings for Which Piling is Not Specified.** Construct structure embankment with granular material Class III within the limits shown on the plans and deposit and compact in accordance with the controlled density method. Compact structure embankment to 100% of the maximum unit weight within the limits of 1:1 slopes, extending outward and downward from the bottom edges of the structure footings.

3. **Winter Grading for Structure Embankment.** Construct embankment during winter weather in accordance with subsection 205.03.H.3 except that before placing embankment to support a structure, remove ground containing frost within the limits of 1:1 slopes spreading outward in every direction from the bottom edges of structure footings. Stockpile frozen material until thawed outside the limits of earth disturbance in areas that are approved by the Engineer.

J. **Machine Grading.** Machine grading consists of light grading, 12 inches deep, to develop the cross section shown on the plans and includes the following:

1. Scarifying;
2. Plowing;
3. Disking;
4. Moving;
5. Compacting; and
6. Shaping the earth.

Loading or hauling material is not required for machine grading.

Grade ditches to drain runoff water. Grade intersections, approaches, entrances, and driveways as shown on the plans or as directed by the Engineer. Obtain the Engineer's approval before using excavation from ditches and roadbeds for shaping shoulders and adjacent fills.

K. **Ditch Cleanout.** Perform ditch cleanout to a depth of no greater than 2 feet based on a typical cross section shown on the plans. Include the following work:

1. Remove cattails, brush, and miscellaneous debris;
2. Remove trees with a diameter of less than 6 inches;
3. Blend ditch profiles to match the existing ditch; and
4. Remove soils/spoils from the project site.

L. **Temporary Railroad Crossing.** Not Used.

M. **Granular Blanket.** Not Used.

N. **Trimming and Finishing Earth Grade.** Construct the earth grade to the required grade. Remove exposed stones and rocks with a diameter greater than 3 inches.

Trim the subgrade to the grade shown on the plans. If a subbase is required, trim the subgrade to within 1 inch of the required grade. If a subbase is not required, trim the subgrade to within ¾ inch of the required grade.

Trim and shape the earth grade outside the subgrade to the required lines, grades, and cross sections. Finish slopes to Class B tolerance unless Class A tolerance is required.

Finish Class A slopes to within 1 inch of the average slopes shown on the plans. Make measurements at right angles to the slope.

Finish Class B backslopes to within 6 inches of the average slopes shown on the plans. Make measurement at right angles to the slope. Do not leave abrupt variations in the finished surface. Remove debris and unsuitable material.

Finish Class B fill slopes to within 2½ inches of the required grade and cross section from the outside shoulder line for 3 feet down the slope. Measure at right angles to the slope. Finish the remainder of the fill slope the same as a Class B backslope.

If trees or other obstacles do not interfere, round the tops of backslopes, bottoms of fill slopes, and other angles in the lines of the cross section to form vertical curves as shown on the plans or as directed by the Engineer. Make vertical curve transitions gradual such that they present a uniform and attractive appearance. The Contractor may omit vertical curves if constructing ditches in peat.

O. **Channel Excavation.** Not Used.

P. **Disposing of Surplus and Unsuitable Material.** The Department assumes no legal obligation to ensure that the Contractor responsibly disposes of surplus and unsuitable material in accordance with this section. Permits must be obtained as necessary in accordance with subsection 107.02.

1. **Disposal Within the Right-of-Way**. Do not dispose of material, temporarily or permanently, beyond the normal plan fill slope across regulated or unregulated wetlands or floodplains. The Engineer may allow disposal of material, including associated restoration material, within the right-of-way to fill low areas or flatten slopes at no additional cost to the Department.

2. **Disposal Outside the Right-of-Way.** Do not dispose of material, temporarily or permanently, in regulated or unregulated wetlands or floodplains. Prior to excavation, obtain written permission from the owner of the property including restoration requirements to be used for disposal outside the right-of-way and file the written permission with the Department. Dispose of material and restore areas in accordance with subsection 205.03.H.2 at no additional cost to the Department.

3. **Contractor Responsibility.** The Contractor is directly and solely responsible for disposal of surplus and unsuitable material.

   Contact the appropriate regulatory agencies to determine whether an area is a regulated or unregulated wetland or floodplain before disposing of surplus or unsuitable material in areas outside the right-of-way and not shown on the plans as disposal sites.

   Immediately move to an upland site any surplus or unsuitable material that was disposed of in portions of regulated or unregulated wetlands or floodplains not shown on the plans as disposal sites, at no additional cost to the Department. Restore the vacated area as directed by the applicable regulatory agencies at no additional cost to the Department.

   The Engineer will not consider requests for extensions of contract time without an assessment of liquidated damages for delays associated with moving surplus or unsuitable material to an upland site.

4. **Notification to Regulatory Agencies.** The Department will notify the applicable regulatory agencies if the Department becomes aware that the Contractor disposed of surplus or unsuitable material in portions of a regulated or unregulated wetland or floodplain not shown on the plans.

5. **Type II Landfill Disposal.** All materials identified as waste and deemed unfit for earthwork balancing on site or in excess once site grading is complete considered under Excavation, Earth or Excavation, Milling Stockpile are required to be disposed of offsite to Type II facilities. A waste manifest for these materials shall be supplied to both the DBRA and the ENGINEER. Unit pricing for these items shall include all testing and documentation requirements from the Type II landfill.

Q. **Berm Grading.** Not Used.

205.04 MEASUREMENT & PAYMENT

A. **Earthwork Volumes.** Prior to the start of the work, the Engineer and Contractor may agree to accept plan quantity, or the Engineer will calculate roadway earthwork volumes using the average end areas, the staked-section method, or an agreed-to alternative method.

The Engineer will determine the average end areas using the cross sections determined from the original and final elevation measurements. An alternative method such as a comparison of digital terrain models may be used if agreed to by the Contractor and the Engineer prior to the start of work.

For the staked-section method, the Engineer will calculate earthwork quantities by comparing the original cross sections taken before construction to the cross sections taken during and after construction.

The Engineer will take measurements during construction to verify conformance to the required grade and cross sections. The Engineer will adjust quantities for the following:

1. Changes in design;
2. Engineer-authorized deviation from the established grade and cross section;
3. Changes in original ground topography after the original survey was made; or
4. Any changes required by the Engineer during construction such as changing of cut or fill slopes and for excavation of peat, muck, marl, and very soft underlying clay.

B. **General.** The cost to build, maintain, remove, and restore borrow haul routes is included in the unit prices for other pay items.

The Engineer will measure removed topsoil to be salvaged as paid for under subsection 816. The Engineer will measure other selected excavated materials from embankment areas as Excavation, Earth.

If the progress clause in the contract requires the Contractor to construct embankments during the seasonal suspension, the Department will pay for the frozen material that is removed and the embankment that is required to replace it at the unit price for Excavation, Earth and Embankment of the type required. The Engineer will direct the grading limits during the seasonal suspension.

The Department will not pay for removing topsoil and frozen material to facilitate the Contractor’s operations.

The unit prices for other pay items include the cost of compacting existing material in embankment and cut sections after removing topsoil.

The Department will pay for the removal of masonry and concrete structures in accordance with section 204.

The Engineer will measure Granular Material, Cl II and Granular Material, Cl III in place. The Engineer will measure Granular Material, Cl III required for constructing fills in water or constructing fills on poorly drained soil as Backfill, Swamp.

The Engineer will measure Underdrains, Bank in accordance with subsection 404.04.

The cost of trimming the subgrade and slopes to the required tolerances is included in the unit prices for other pay items.

The cost of restoring borrow and disposal areas is included in the unit prices for other pay items.

C. **Excavation, Rock.** Not Used.

D. **Peat Excavation and Swamp Backfill.** Not Used.

E. **Subgrade Undercutting and Subgrade Manipulation**

1. **Subgrade Undercutting.** Not Used.

2. **Subgrade Manipulation.** Not Used.

F. **Earth Excavation and Embankment.** The cost of stepping side slopes is included in the unit prices for the related roadway embankment pay items.

1. **Embankment, LM.** Not Used.

2. **Excavation, Earth and Embankment, CIP.** Payment for Excavation, Earth will be based on subsection 205.04.A.

   If material is removed in embankment areas to a greater depth than required, the Department will pay only for the quantities of Excavation, Earth as shown on the plans or as directed by the Engineer.

3. **Embankment, Structure, CIP.** Not Used.

G. **Machine Grading.** Not Used.

H. **Ditch Cleanout.** Not Used. Restoration will be paid for separately in accordance with section 816.

I. **Granular Blanket**

1. **Granular Blanket, Type 1**. Not Used.

2. **Granular Blanket, Type 2.** Not Used.

J. **Channel Excavation.** Not Used.

K. **Berm Grading.** Not Used.

205.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-205.05.01	Excavation, Earth	Cubic Yard (CY)
MDOT-205.05.02	Excavation, Milling Stockpile	Cubic Yard (CY)
MDOT-205.05.03	Excavation, Earth - Bid Alt 1	Cubic Yard (CY)
MDOT-205.05.04	Excavation, Milling Stockpile - Bid Alt 1	Cubic Yard (CY)

END OF ITEM MDOT-205

Item MDOT-208 Soil Erosion and Sedimentation Control

208.01 DESCRIPTION

This work consists of installing and maintaining erosion and sedimentation controls to minimize soil erosion and control sediment from leaving the right-of-way and affecting water resources of the State of Michigan and adjacent properties. Complete this work in accordance with this section and MDOT's SESC Manual. The Department considers the terms "stabilization" and "erosion control measures" as defined in the SESC Manual.

Failure to install and maintain soil erosion controls may result in project shutdown, fines from the EGLE, or both. The Contractor is responsible for obtaining applicable federal, state, and local permits when disturbing areas outside a Department right-of-way or outside Department-acquired easement areas.

208.02 MATERIALS

Provide materials in accordance with the following sections:

Coarse Aggregate, 6A 902
Granular Material Class II 902
Dense-Graded Aggregate, 21AA, 22A 902
Open-Graded Aggregate, 34R, 46G 902
Fencing Materials 907
Culvert Pipe 909
Geosynthetics 910
Cobblestone 916
Coarse Aggregate, 3×1 916
Riprap 916
Heavy Riprap 916
Sand And Stone Bags 916
Temporary Plastic Sheet 916
Turbidity Curtain 916

208.03 CONSTRUCTION

A. **Area Limitations.** Conduct work to minimize soil erosion.

Limit the area of earth disturbance to 50 stations of dual roadways or 100 stations of single roadway during clearing and grading. The Engineer may change the limits of exposed surface area based on the Contractor's ability to minimize erosion and prevent offsite sedimentation.

Do not disturb lands and waters outside the limits of earth disturbance within the right-of-way without prior approval from the Engineer. Restore Contractor-disturbed areas beyond the plan or Engineer-approved limits at no additional cost to the Department.

Obtain and give the Engineer copies of local, state, or federally required permits before disturbing sites outside the right-of-way, such as borrow, waste or disposal areas, haul roads, or storage sites. Provide temporary and permanent erosion and sedimentation controls in accordance with the permits.

B. **Time Limitations.** Bring grading sections to the final earth grade as soon as possible. Completion of the final earth grade does not include topsoil or other permanent restoration measures. The Engineer will consider the earth grade final and ready for placement of topsoil and permanent soil erosion control measures when the Contractor constructs a slope, channel, ditch, or other disturbed area in accordance with subsection 205.03.N.

Complete topsoil placement and stabilize slopes, channels, ditches, and other disturbed areas within 5 calendar days after final earth grade with permanent soil erosion control measures. Permanently restore and place topsoil on slopes and ditches within 150 feet of lakes, streams, or wetlands within 24 hours of achieving final earth grade using permanent soil erosion control measures.

Do not prolong trimming, finishing final earth grade, or both, to permanently stabilize the project at one time.

C. **Construction and Maintenance of Erosion and Sedimentation Controls.** Construct temporary or permanent erosion and sedimentation controls in accordance with the SESC Manual, details shown on the plans, or as directed by the Engineer.

Maintain temporary erosion and sedimentation controls as necessary to ensure their effectiveness until permanent stabilization of the disturbed area has occurred. Dispose of sediment and debris removed from temporary sedimentation control devices in accordance with subsection 205.03.P.

Maintain permanent erosion controls as necessary to ensure their effectiveness until project completion and acceptance. Repair damaged areas, replace lost devices, and remove sediment as required. Dispose of sediment and debris removed from permanent sedimentation control devices in accordance with subsection 205.03.P.

1. **Check Dams.** Not Used.

2. **Sediment Traps and Basins.** Excavate 5 cubic yards or less for sediment traps and greater than 5 cubic yards for sediment basins. Construct, maintain, and fill sediment traps and basins.

   Prevent the excavated material from eroding into lakes, watercourses, or wetlands. Install required check dams downstream from a trap or basin before excavating the trap or basin.

3. **Filter Bag.** Not Used.

4. **Sand and Stone Bags.** Not Used.

5. **Silt Fence.** Provide, install, maintain, remove, and dispose of silt fence consisting of woven geotextile fabric stapled to and supported by posts. Place material removed from trenching in the silt fence on the upslope side of the silt fence. In areas where water ponds

behind the silt fence, provide a stone filter to channel away the water and prevent failure. Silt fence may remain in place after the required period if directed by the Engineer.

6. **Gravel Filter Berm.** Not Used.

7. **Inlet Protection, Fabric Drop.** Not Used.

8. **Inlet Protection, Geotextile and Stone.** Not Used.

9. **Inlet Protection, Sediment Trap.** Excavate, provide, maintain, remove, and dispose of sediment traps consisting of geotextile blanket and coarse aggregate 6A or open-graded aggregate 34R or 46G. Remove and dispose of accumulated sediment as necessary.

10. **Temporary Plastic Sheets or Geotextile Cover.** Not Used.

11. **Sand Fence.** Not Used.

12. **Aggregate Cover.** Not Used.

13. **Gravel Access Approach.** Provide, place, maintain, remove, and dispose of geotextile separator and coarse aggregate 3×1 or other Engineer-approved material.

14. **Turbidity Curtain.** Not Used.

15. **Intercepting Ditch.** Not Used.

D. **Removal of Erosion and Sedimentation Control Facilities.** Remove or obliterate temporary erosion and sedimentation controls when the permanent controls are complete and approved unless otherwise directed by the Engineer. Do not remove temporary controls next to lakes, watercourses, or wetlands until the establishment of turf on the adjacent slopes. Before placing topsoil, permanent seed, and fertilizer, remove or incorporate mulch placed for temporary erosion control into the slope. Minimize erosion and sedimentation into watercourses during removal of erosion controls. Repair damage caused during the removal of erosion controls at no additional cost to the Department.

208.04 MEASUREMENT AND PAYMENT

The Department will not pay for repairing or replacing temporary or permanent SESC measures damaged by the Contractor's negligence. The Department will pay for repairing or replacing temporary or permanent SESC measures damaged by causes other than the Contractor's negligence at the contract unit price for the relevant pay items.

A. **Erosion Control, Check Dam, Stone.** Not Used.

B. **Erosion Control, Sediment Trap or Basin**

1. **Erosion Control, Sediment Trap.** The unit price for Erosion Control, Sediment Trap includes the cost of excavating, constructing, maintaining, and removing sediment traps.

   Removing and disposing of accumulated sediment or debris from a sediment trap shall be incidental to this pay item.

2. **Erosion Control, Sediment Basin.** Not Used.

C. **Erosion Control, Filter Bag.** Not Used.

D. **Erosion Control, Sand Bag and Erosion Control, Stone Bag**. Not Used.

E. **Erosion Control, Silt Fence**. The Engineer will measure Erosion Control, Silt Fence in place excluding overlaps. The unit price for Erosion Control, Silt Fence includes the cost of providing, installing, maintaining, removing, and disposing of the fence and posts.

Removing and disposing of accumulated sediment or debris from behind silt fence shall be incidental to this pay item.

F. **Erosion Control, Gravel Filter Berm**. Not Used.

G. **Erosion Control, Inlet Protection**

1. **Erosion Control, Inlet Protection, Fabric Drop.** Not Used.

2. **Erosion Control, Inlet Protection, Geotextile and Stone.** Not Used.

3. **Erosion Control, Inlet Protection, Sediment Trap.** The unit price for Erosion Control, Inlet Protection, Sediment Trap includes the cost of excavating, constructing, maintaining, and removing sediment traps for inlet protection.

Removing and disposing of accumulated sediment or debris from a sediment trap inlet protection shall be incidental to this pay item.

H. **Erosion Control, Temporary Plastic Sheet/Geotextile Cover.** Not Used.

I. **Erosion Control, Sand Fence.** Not Used.

J. **Erosion Control, Aggregate Cover.** Not Used.

K. **Erosion Control, Gravel Access Approach**. The unit price for Erosion Control, Gravel Access Approach includes the cost of temporary culverts and ditching required to maintain existing drainage courses through or around gravel access approaches and providing, constructing, maintaining, and removing gravel access approaches.

L. **Erosion Control, Maintenance, Sediment Rem.** Not Used.

M. **Erosion Control, Turbidity Curtain.** Not Used.

N. **Intercepting Ditch.** Not Used.

208.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-208.05.01	Erosion Control, Silt Fence	Linear Feet (LF)
MDOT-208.05.02	Erosion Control, Inlet Protection, Sediment Trap	Each (EA)
MDOT-208.05.03	Erosion Control, End Section Protection	Each (EA)
MDOT-208.05.04	Erosion Control, Gravel Access Approach	Each (EA)
MDOT-208.05.05	Erosion Control, Inlet Protection, Sediment Trap - Bid Alt 1	Each (EA)
MDOT-208.05.06	Erosion Control, Silt Fence	Linear Feet (LF)
MDOT-208.05.07	Erosion Control, Gravel Access Approach	Each (EA)

END OF ITEM MDOT-208

Item MDOT-302 Aggregate Base Course

302.01 DESCRIPTION

This work consists of constructing an aggregate base course on a surface approved by the Engineer.

302.02 MATERIALS

Provide materials in accordance with the following section:

Dense-Graded Aggregate 21AA, 21A, 22A……902

Provide aggregate meeting the aggregate series shown on the plans.

302.03 CONSTRUCTION

A. **Placing and Compacting.** Provide a ticket with each load stating the following information:

1. Project number;
2. Aggregate source;
3. Aggregate series;
4. Date;
5. Time;
6. Truck identifier number;
7. Supplier name; and
8. Type of aggregate approval.

If the contract requires payment by weight, ensure the ticket includes the gross weight, tare weight, and net weight to the nearest 100 pounds.

Determine the truck tare weight at least once daily.

If the contract does not require payment by weight, the Engineer may accept written documentation instead of tickets. Written documentation must identify the pay item of the material and include all of the information listed above except time and truck identifier number.

Provide and place aggregate with a uniform gradation, free of contamination and segregation. Do not place aggregate base on frozen, soft, unstable or rutted subgrade, subbase, or aggregate base. Do not rut or distort the subbase material or aggregate base during spreading.

The Contractor may use additives to facilitate compaction, shaping, and maintenance of the aggregate surface.

Compact the aggregate layers to a uniform thickness, no less than 3 inches and no greater than 8 inches. If placing aggregate base in a layer less than 3 inches, blend the new aggregate base material with the layer below to ensure a total of 6 inches. Blending must be performed to ensure that the new aggregate base material is uniformly mixed with the layer below.

Compact each layer of aggregate base to at least 98% of the maximum unit weight at a moisture content no greater than optimum for aggregate base under hot mix asphalt (HMA) pavement. Compact each layer of aggregate base to at least 95% of the maximum unit weight

at a moisture content no greater than optimum for aggregate base under concrete pavement. Within the limits of bridge approaches, from the abutment wall to the typical roadway cross section, compact each layer of the aggregate base to at least 98% of the maximum unit weight. Shape the finished surface and the layer thickness to within ±½ inch of the crown and grade shown on the plans.

Remove, dispose of, and replace aggregate base material that mixes with subbase or subgrade material at no additional cost to the Department.

a. Conditioning Aggregate Base. Shape the finished surface of the existing aggregate base course to within ±½ inch of the grade and cross section shown on the plans. Provide additional aggregate to address irregularities and obtain the required grade or cross section.

B. If placing aggregate base in a layer less than 3 inches, blend the new material with the layer below to ensure a total of 6 inches. Blending must be performed to ensure that the new material is uniformly mixed with the layer below and compacted as specified in subsection 302.03.A.

C. **Maintenance During Construction.** Maintain the aggregate base course layer at the required line, grade, and cross section until placement of the next layer. Ensure the exposed aggregate base course layer remains smooth, compacted, and uncontaminated.

If the subgrade, subbase, or aggregate base is damaged due to the Contractor's operations or construction traffic, restore to the required condition at no additional cost to the Department.

D. **Surplus Existing Aggregate Base Material.** Surplus existing aggregate base material meeting the material requirements described in this section may be used instead of providing new aggregate base material. Remove and dispose of surplus aggregate base material not being used elsewhere on the project and any unsuitable material in accordance with subsection 205.03.P.

302.04 MEASUREMENT AND PAYMENT

A. **Aggregate Base.** The Engineer will measure Aggregate Base, by width, depth, and length for the specified depth as shown on the plans.

B. **Aggregate Base, LM.** Not Used.

C. **Aggregate Base, __inch.** Not Used.

D. **Aggregate Base, Conditioning.** Not Used.

E. **Aggregate Base, Conditioning, Surplus and Unsuitable, Rem, LM.** Not Used.

F. **SALV AGGREGATE BASE, CONDITIONING, LM.** Not Used.

302.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-302.05.01	Aggregate Base	Cubic Yard (CY)
MDOT-302.05.02	Aggregate Base – Bid Alt 1	Cubic Yard (CY)

END OF ITEM MDOT-302

Item MDOT-308 Geosynthetic for Base

308.01 DESCRIPTION

This work consists of providing and installing geosynthetic products on a surface approved by the Engineer.

308.02 MATERIALS

Provide material in accordance with the following sections:

Geotextile Separator……910

Stabilization Geotextile……910

Road Grade Biaxial Geogrid……910

308.03 CONSTRUCTION

A. **Geotextile Placement.** Place or install geotextile separator or stabilization geotextile products in accordance with the manufacturer's installation guidelines and this subsection.

Do not operate equipment that is required to place backfill directly on geotextile products. Eliminate wrinkles or waves that develop during placement. Place the products in direct contact with the soil below before placing backfill on the geotextile products. Do not expose geotextile to ultraviolet degradation for more than 7 days.

Shingle-lap longitudinal and transverse joints at least 2 feet or seam the joints in accordance with the manufacturer's recommendations. Ensure that field or factory seams meet the minimum grab tensile strength for the product application. Do not use nylon thread for geotextile seaming. Place seams facing upward for inspection purposes. Repair tears or damage to the geotextile in accordance with the manufacturer's recommendations.

B. **Geogrid Placement.** Not Used.

C. **Aggregate or Granular Material Placement.** Not Used.

308.04 MEASUREMENT AND PAYMENT

A. **General.** The Engineer will measure Geotextile, Separator; Geotextile, Separator, Non-Woven; Geotextile, Stabilization; Geotextile, Stabilization, Non-Woven; and Road Grade Biaxial Geogrid in place to the limits shown on the plans.

Geotextile, Separator; Geotextile, Separator, Non-Woven; Geotextile, Stabilization; and Geotextile, Stabilization, Non-Woven include furnishing the material, labor, and equipment required to furnish and place geotextiles and all materials and labor required to create seams. No allowance will be made for overlap, splices, or material cut off or wasted.

Road Grade Biaxial Geogrid includes furnishing the material, labor, and equipment required to furnish, place and anchor the geogrid, and any hand work necessary to establish grades and make geogrid splices. No allowance will be made for overlap, splices, or material cut off or wasted.

THE COST OF AGGREGATE OR GRANULAR MATERIAL, INCLUDING ADDITIONAL QUANTITIES REQUIRED TO FILL RUTS, IS INCLUDED IN THE UNIT PRICES FOR RELATED PAY ITEMS.

All jobsite posters and employment notices required by state and federal regulations and the contract are to be posted in a conspicuous place. Posting of jobsite posters and employment notices (posted display, foreman vehicle binder, etc.) For short-term or mobile operations will be as approved by the engineer.

308.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-308.05.01	Geotextile, Separator	Square Yard (SY)
MDOT-308.05.02	Geotextile, Separator – Bid Alt 1	Square Yard (SY)

END OF ITEM MDOT-308

Item MDOT-402 Storm Sewers

402.01 DESCRIPTION

This work consists of constructing storm sewers of the size and class required, including excavation, bedding, and backfill.

The following terms apply to this section:

Type HE. An elliptical pipe placed with the major axis in the horizontal direction.

Type VE. An elliptical pipe placed with the major axis in the vertical direction.

402.02. MATERIALS

Provide materials in accordance with the following sections:

Granular Material Class II, III, IIIA 902
Aggregate 6A, 17A, 34R, 46G..... 902
Sewer Pipe 909
Sealers for Sewer Joints..... 909
Steel Pipe (for jacking in place) 909
Geosynthetics..... 910
Concrete, Grade 3000..... 1004
Mortar, Type R-2..... 1005

Select pipe with watertight joint systems from the Qualified Products List.

Storm sewers are divided into five classes, as specified in Table 402-1. If the contract specifies only the size and class of sewer, select and provide an alternative storm sewer pipe allowed in Table 402-1.

For types of sewer material that are required but are not included in Table 402-1, the contract will specify the type and size of sewer material.

A higher strength or greater thickness of sewer may be substituted for the minimum required sewer strength or minimum required thickness.

Table 402-1: Pipe Alternatives for Storm Sewer Classes

Type of Pipe	Storm Sewer Class (depth of cover, feet[a])				
	Class A Sewer (1–10)[b][c]	Class B Sewer (>10–16)	Class C Sewer (>16–23)	Class D Sewer (>23–33)[c]	Class E Sewer (1–3)[c][d]
Reinforced concrete[e]	II	III	IV	V	IV
Nonreinforced concrete[f]	1	3	No	No	No
Corrugated and spiral ribbed al-alloy[g]	Yes	Yes	Yes	Yes	No
Corrugated and spiral ribbed steel[h]	Yes	Yes	Yes	Yes	No
Dual-wall polymer-precoated galvanized steel	Yes	Yes	Yes	Yes	No
Smooth-lined corrugated plastic (CPE)[i]	Yes[j][k]	Yes[k][l]	No	No	No
Corrugated polyvinyl chloride (CPV)[m]	Yes[j][k]	Yes[k][l]	No	No	No

(a) Cover, including the pavement structure is defined as the height of fill above the top of the pipe measured to finalgrade.
(b) Class A sewer applies when the sewer is outside the influence of proposed pavement or is beneath the influence of proposed pavement and the depth of cover is >3 feet but ≤10 feet.
(c) Special design is required for depths of cover <1 foot and >33 feet.
(d) Class E Sewer applies when the sewer is beneath the influence of proposed pavement and the depth of cover is ≤3feet.
(e) Roman numerals refer to class of reinforced concrete pipe in accordance with AASHTOM170.
(f) Arabic numerals refer to the class of nonreinforced concrete pipe in accordance with AASHTOM86.
(g) Allowed for 12- to 66-inch spiral ribbed and 12- to 18-inch helically corrugated 2⅔ by ½ inch aluminum alloy pipeonly.
(h) Allowed for 12- to 84-inch spiral ribbed and 12- to 18-inch helically corrugated 2⅔ by ½ inch steel pipeonly.
(i) Provide CPE in accordance with AASHTO M294, Type S polyethylenepipe.
(j) Allowed only for 36-inch-diameter pipe and under for CPE and CPV pipes. At least 3 feet ofcover.
(k) Refer to the ClassA, B and F Bury Plastic Pipe Qualified Products List for approved manufacturers and products.
(l) Allowed only for 12- to 24-inch diameter CPE and CPV pipes.
(m) CPV must conform to AASHTOM304.

402.03. CONSTRUCTION

A. **Excavation, Trench Construction, and Sewer Bedding.** Perform trench construction using methods that meet the health and safety requirements specified in subsection 104.07.

Excavate the trench as shown on the plans or as determined by the Engineer. Construct the trench width to at least the minimum width shown in the *MDOT Standard Plan R-83* series and wide enough to provide free working space and allow compaction of the backfill around the pipe.
Shape the bottom of the trench to support the pipe uniformly. Place bedding using uncompacted granular material Class IIIA to the required elevation.

Where unstable soil conditions or obstructions other than rock require excavation of the trench below the elevation detailed on the plans, undercut, backfill, and compact the trench as directed by the Engineer. Use 6A, 17A, 34R, or 46G aggregate as backfill material for undercutting due to unstable soil conditions. Use 34R aggregate for bedding material instead of granular material Class IIIA. Place the backfill up to 4 inches below the proposed bottom of the pipe. The completed work will be paid for as Trench Undercut and Backfill according to subsection 402.04.E.

During sewer construction, maintain and protect existing live utilities. Minimize service interruptions and coordinate with the local municipality or utility company. Immediately repair or replace utilities interrupted during sewer construction as directed by the Engineer.

B. **Repair of Damaged Coated Surfaces.** Repair coated pipe surfaces damaged during pipe transportation, handling, or installation, at no additional cost to the Department. Complete repair of galvanized pipe surfaces in accordance with subsection 716.03.E or as approved by the Engineer. Repair other coated sewer pipe surfaces as directed by the Engineer.

C. **Laying and Jointing Pipe.** Lay storm sewers as shown on the plans with bells or grooves upgrade and ends fully and closely jointed. Provide a full, firm bearing along the length of each pipe section. Wrap all pipe joints with geotextile blanket. Use geotextile at least 36 inches wide and center it on the joint. Overlap the ends of the geotextile blanket at least 12 inches.

Remove and replace pipe damaged by Contractor operations. After trench backfill and compaction is complete, mandrel test replaced CPE and CPV pipe. Remove and re-lay sewer sections showing signs of settlement or poor horizontal or vertical alignment as determined by the Engineer at no additional cost to the Department.

1. **Corrugated Plastic Pipe (CPE and CPV).** Provide homing marks on CPE and CPV pipe sections and joint material to show the correct alignment of the pipe sections and joint material during field installation.

   After trench backfill and compaction is complete, the Engineer will select at least 50% of the installed length of each size of CPE and CPV pipe for deformation testing. Provide the labor and equipment that are required to complete the testing.

   Unless otherwise approved by the Engineer, perform the mandrel test within 10 work days prior to pavement surfacing or completion of final grade.

   Use a nine-point mandrel with a diameter equal to 95% of the nominal pipe diameter. Provide the Engineer with a proving-ring to verify the mandrel size. Pull the mandrel through the pipe by hand using non-mechanical means and without damaging the pipe. The Contractor may use laser profile technology to measure deflection as an approved alternative to mandrel testing.

   Remove and reinstall or replace pipe with a nominal diameter reduced by at least 5% at no additional cost to the Department. Reinstall only undamaged pipe. Do not reinstall pipe without the Engineer's approval.

   The Contractor is responsible for all expenses and delays caused by reinstallation or replacement of pipe.

2. **Concrete Pipe.** Install reinforced concrete elliptical pipe with the longer axis placed horizontally unless otherwise required.

   Install Type HE elliptical pipe with the longer axis within 5 degrees of horizontal.

   Install Type VE elliptical pipe with the longer axis within 5 degrees of vertical.

   Install circular concrete pipe with elliptical reinforcement so the lift holes or manufacturer's marks are on the top of the pipe. Place pipe so the lift holes or manufacturer's marks designating the top and bottom of the pipe are no more than 5 degrees from the vertical

plane through the longitudinal axis of the pipe. After installing the pipe, seal the lift holes with concrete plugs and waterproof.

3. **Metal Pipe.** Provide metal pipe with helical corrugations with a continuous lock seam in accordance with subsection 909.05.

   Use of dissimilar types of base metal (steel or aluminum alloy) or dissimilar types of coatings on steel (zinc or aluminum) in a single line of pipe is prohibited. Construction between dissimilar metal type pipes is not allowed unless a drainage structure is used to transition between the two dissimilar type metals. Changing materials at the drainage structure is allowed if the roughness coefficients have been adjusted accordingly. Use coupling bands of the same base metal and coating metal as the pipe.

D. **Sewer Taps.** Make connections to storm sewers owned by counties, municipalities, or drain commissions in accordance with the regulations of the owner and as required by the contract. If a conflict exists between the owner's regulations and these specifications, the owner's regulations will take precedence.

   For existing storm sewers with plugs or bulkheads, remove plugs or bulkheads without damaging the existing sewer and make watertight joint connections. Remove material in accordance with subsection 204.03.B.

   If tapping an existing pipe, cut an opening in the receiving pipe at least 6 inches larger than the outside diameter of the inlet pipe. Insert the inlet pipe and cut flush with the inner wall of the receiving pipe. Pack a layer of mortar at least 3 inches thick around the inlet pipe and strike smooth with the inner wall of the receiving pipe. Encase the inlet pipe on the outside of the connection with concrete to provide bearing under the pipe. Repair or replace existing pipe damaged by Contractor tapping operations at no additional cost to the Department.

   Do not direct tap sewer inlet pipes with outside diameters greater than half the inside diameter of the trunk sewer. Construct a manhole structure for these taps in accordance with section 403. Obtain the Engineer's approval before using other methods of tapping existing sewers.

E. **Sewer Bulkheads.** Construct sewer bulkheads using Grade 3000 concrete or brick or block masonry. Extend the bulkhead at least 1 foot into the pipe from the inner wall of the drainage structure. Construct masonry bulkheads in accordance with subsection 403.03.A.

F. **Backfilling.** Backfill in accordance with subsection 401.03.D.

G. **Sewer Jacked in Place.** Jack sewers in place in accordance with subsection 401.03.G.

H. **Disposal of Surplus Material.** Take possession and dispose of surplus material in accordance with subsection 205.03.P.

I. **Cleanout.** Maintain storm sewers installed on the project. Verify that installed sewers are free of silt, debris, and other deleterious material at the time of final acceptance and in accordance with section 209.

J. **Video Inspection of Sewer Pipe.** Use closed circuit television to inspect required storm sewers. Dewater or divert flow in sewers for inspection. Video inspection is not required for extensions of existing catch basin leads less than 20 feet.

After backfilling and compacting the trench, and within 10 working days prior to pavement surfacing or completion of final grade, conduct the inspection of sewers under pavement unless otherwise approved by the Engineer.

For sewers not under pavement, after backfilling and compacting the trench, conduct the inspection as close to project completion as possible but allow time for corrective action as determined by the video inspection and directed by the Engineer.

1. **Traffic Control.** Obtain the Engineer's approval of traffic control measures at least 5 days before beginning work. Propose a traffic control plan in accordance with the *Michigan Manual of Uniform Traffic Control Devices* (MMUTCD) and the maintaining traffic plans in the contract.

   Unless otherwise approved by the Engineer, keep traffic lanes open. For necessary lane or shoulder closures, use traffic control measures in accordance with the traffic control plan.
2. **Equipment.** Use a camera designed and constructed for inspecting sewers and equipped with the following features:

   a. A pan and tilt head external to the main body of the camera to allow inspection of the sewer joints and cracks or other defects;

   b. Lighting to allow a clear picture of the perimeter of the pipe; and

   c. Underwater operation capable of producing a picture quality that is satisfactory to the Engineer.

   d. Show or document camera magnification at all times in the video. If the Engineer determines the video quality is not satisfactory, re-inspect the pipes to obtain acceptable results at no additional cost to the Department.

   Use continuous running video capable of recording audio and video information. Include the date (month, day, and year) and camera location. Provide a continuous record of the sewer section from manhole to manhole or from end to end. Use high quality, color, digital format at a standard play speed. Obtain the Engineer's approval before using other recording media.
3. **Sewer Flow Control.** For video inspection, provide flow control to bring the depth of flow in the sewer pipe to within the range specified in subsection 402.03.J.6.a. Before starting work, submit the proposed method of sewer flow control to the Engineer for approval.
   a. **Depth of Flow.** Lower the depth of flow in the sewer during the videotaping operation to less than 2 inches. Reduce flow by plugging or blocking the flow or by pumping the flow and bypassing the pipe section during inspection, as approved by the Engineer.
   b. **Plugging or Blocking.** Insert a sewer line plug into the line upstream of the section undergoing inspection. Use a plug designed to allow the release of portions of the flow. During video inspection, reduce the flow depth to 2 inches. Restore normal flow after completing the work. Meter flow discharge to prevent erosion.

   c. **Pumping and Bypassing.** For pumping and bypassing, supply the pumps, conduits, and other equipment to divert the flow around the sewer section undergoing inspection. Provide a bypass system with a capacity to handle existing flow plus additional flow that may occur during a rain event. Provide the labor and supervision required to set up and

operate the pumping and bypassing system.

d. **Flow Control Precautions.** If the flow in a sewer line is plugged, blocked, or bypassed, protect the sewer lines from damage that may result from sewer surcharging. Do not cause flooding or damage to public or private property while controlling sewer flow.

4. **Procedure.** Move the camera through the line at a rate no greater than 0.5 feet per second, stopping as required to document the joint and pipe conditions. Use winches, cable, powered rewinds, or other devices that do not obstruct the camera view or interfere with proper documentation of the pipe conditions.

   Adjust the camera to travel above the level of the flow in the pipe. If the camera encounters a dip in the pipe such that the water rises above the springline of the pipe or if the camera lens becomes submerged, withdraw the camera and re-insert it from the other end as far as possible. Do not back the camera into a pipe undergoing inspection.

   Measure the distance to the location of defects above ground using a meter device. Marking defect locations on the cable to measure the distance to defects is not allowed. Provide a distance meter with an accuracy within 1 foot and check using a walking meter, roll-a-tape, or other device.

5. **Documentation.** Provide the inspection to the Engineer in a digital format. Include a written log of damages or installation defects, including pipe deformation, cracking, joint separation, corrosion, perforation, and other features identified in the video. Provide a digital copy of the log to the Engineer. Locate the damage or defect by meter marking of the video in the inspection log. Label the videos to describe the reaches of sewer or culverts contained in the videos, including street location and manhole numbers. If manhole numbers are not provided, assign a numbering system to allow identification in the inspection report and video.

402.04. MEASUREMENT AND PAYMENT

A. **Sewer.** The Engineer will measure Sewer of the size and class required, in place from center to center of manholes, catch basins, or inlets. The unit price for Sewer includes the cost of excavation, backfill, and geotextile blanket.

B. **Sewer, Jacked in Place.** Not Used.

C. **Sewer Tap.** Not Used.

D. **Sewer Bulkhead.** Not Used.

E. **Trench Undercut and Backfill.** Not Used.

F. **Rock Excavation.** Not Used.

G. **Dewatering System, Trench.** Not Used.

H. **Trenchless.** Not Used.

I. **Video Taping Sewer and Culvert Pipe.** Not Used.

J. **Obstructions.** Not Used.

402.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-402.05.01	Sewer, Cl V, 12 inch	Linear Foot (LF)
MDOT-402.05.02	Sewer, Cl V, 18 inch - Bid Alt 1	Linear Foot (LF)
MDOT-402.05.03	Sewer, Cl V, 12 inch - Bid Alt 1	Linear Foot (LF)

END OF ITEM MDOT-402

Item MDOT-403 Drainage Structures

403.01 DESCRIPTION

This work consists of adjusting, constructing, or temporarily lowering drainage structures and cleaning existing drainage structures and leads as directed by the Engineer.

Drainage structures include manholes, catch basins, leaching basins, inlets, and drop inlets.

Drainage Structure. Includes concrete footing or precast sump. Used for access to new or existing sewers with a diameter no greater than 48 inches.

Manhole Base, Type 1 or Type 2, and Manhole Riser. Used for access to new or existing sewers with a diameter of at least 48 inches. Manhole Base Type 1 may be substituted for Precast Manhole Tees. **Precast Manhole Tee and Manhole Riser.** Used for access to new sewers with diameters of at least 42 inches.

Manhole Base, Type 1 or Type 2, and Manhole Riser. Used for access to new or existing sewers with a diameter of at least 48 inches. Manhole Base Type 1 may be substituted for **Precast Manhole Tees**.

403.02 MATERIALS

Provide materials in accordance with the following sections:

Granular Material Class II, III..... 902

Steel Reinforcement 905

Miscellaneous Metal Products 908

Castings……..... 908

Culvert, Sewer Pipe, and Box Sections 909

Geosynthetics……..... 910

Masonry Units…..... 913

Concrete, Grade 3000..... 1004

Mortar Type R-2..... 1005

Provide cast-in-place or precast concrete construction for sanitary sewer manholes.

Provide structural steel plate, at least ½ inch thick, for temporary lowering of drainage structures that span 72 inches or less. Verify that plates cover the entire drainage structure with a bearing surface of at least 12 inches. For plates that span greater than 72 inches, submit structural calculations prepared by a Professional Engineer licensed in the State of Michigan to the Engineer.

Provide leveling course hot mix asphalt (HMA) for patching during the temporary lowering operations or other HMA mixture as approved by the Engineer.

403.01. CONSTRUCTION

A. Constructing, Adjusting, and Temporary Lowering of Drainage Structures, Precast Manhole Tees, Manhole Bases, and Manhole Risers

1. **Excavation.** Excavate for constructing, adjusting, and temporarily lowering drainage structures, precast manhole tees, manhole bases, and manhole risers in accordance with subsection 206.03.A.

2. **Concrete Construction.** Construct concrete portions of drainage structures in accordance with subsection 706.03. Do not cast drainage structures if the concrete temperature is above 90°F.

3. **Placing Brick and Block Masonry.** Do not place masonry with mortar when the ambient air temperature is 36°F or less unless approved by the Engineer. Remove and replace work damaged by frost. Apply a ½-inch-thick plaster coat of mortar to the outer surface of structures and to the inner surface below the outlet flow line on catch basins with traps or sumps. Place the first set of bricks or blocks on a full bed of mortar. Lay brick or block in courses with uniform mortar joints ½ inch thick within ⅛ inch of depth. Stagger joints by half the length of the brick or block on adjoining courses. Place courses level unless otherwise required. Strike and point joints so the exposed surface is smooth. Rake joints and wet brick or block before placing the plaster coat. Allow the brick or block surface to dry to provide for proper bonding of the plaster coat.

   Wet the brick. Allow the brick surface to dry to allow the brick and mortar to bond. Use of broken or chipped brick on the faces of the structure is prohibited. Provide a course made of headers at least every seventh course. Make closures with brick lengths no less than the width of a whole brick.

4. **Precast Reinforced Concrete Units.** Use poured-in-place concrete in accordance with subsection 403.03.A.2 or precast concrete footings. Construct precast reinforced concrete units in accordance with the contract. Seal the joints with mortar in accordance with subsection 403.03.A.3, or use butyl rubber sealant that conforms to ASTM C990. Support precast concrete footings on a 6-inch subbase of compacted granular material Class II.

5. **Steel Reinforcement.** Install steel reinforcement in accordance with subsection 706.03.

6. **Inlet and Outlet Pipes.** Place and compact backfill around the manhole base or sump to provide bedding for inlet and outlet pipes.

   Extend inlet and outlet pipes through the outside wall surface of the manhole a sufficient length to allow for pipe connections. Construct masonry around pipes and seal with mortar or other product approved by the Engineer to prevent leakage.

7. **Backfilling.** Backfill in accordance with subsection 401.03.D.

   Stage backfilling to coordinate with the construction sequencing of the structure as necessary.

8. **Temporary Lowering of Drainage Structures.** Lower drainage structures before milling the pavement.

Record the location of the structure so each cover can be reinstalled at its original location. Remove the existing frames and covers and match mark them for later identification and placement. Salvage and safely store frames and covers. Repair the existing structure to allow uniform contact of the steel plate to the top of the structure. Place and compact the HMA for patching in accordance with section 501.

9. **Protection during Construction.** Install inlet protection devices in accordance with section 208 and as approved by the Engineer when working around the drainage structure.

B. **Drainage Structure Covers.** Provide and install new covers, including frames and grates, on new or existing structures as required. Place castings on a full mortar bed.

C. **Adjusting Drainage Structure Covers.** Adjusting drainage structure covers applies when the new elevation of the cover requires a vertical change of no greater than 6 inches. Before placing the HMA top course or overlay, make final adjustments to drainage structure covers within the HMA pavement section if only applying one course. Adjust the cover to the required elevation by supporting it on one of the following:

1. Metal ring adjustor;
2. Precast concrete adjusting ring;
3. Masonry in a full mortar bed; or
4. Alternate adjustor selected from the Qualified Products List.

Hold adjusted covers in place. Remove and replace the adjacent pavement, curb, or curb and gutter to match the existing grades or the required new elevations.

D. **Additional Depth of Adjusting Drainage Structures.** Additional depth of adjusting drainage structure covers applies when a drainage structure cover is adjusted more than 6 inches from the existing cover elevation due to a change in elevation of the roadway or when alterations to the drainage structure exceed 6 inches regardless of the change in cover elevation. Remove damaged or unsound portions of the structure as directed by the Engineer and adjust as required.

E. **Drainage Structure Taps.** Make connections to existing drainage structures owned by counties, municipalities, or drain commissions in accordance with the owner's regulations and the contract. If a conflict exists between the owner's regulations and these specifications, the owner's requirements take precedence.

If tapping an existing drainage structure, cut an opening into the receiving structure at least equal to the outside diameter of the inlet pipe plus

6 inches and insert the pipe. Pack a layer of mortar at least 3 inches thick around the inlet pipe and strike smooth with the inner wall of the receiving structure. Repair or replace existing drainage structure damaged by Contractor operations during tapping at no additional cost to the Department.

Tap directly to a sewer or culvert in accordance with subsection 402.03.D.

F. **Cleanout.** Maintain catch basins, manholes, leaching basins, and inlets installed on the project. Ensure that installed catch basins, manholes, leaching basins, and inlets are free of silt, debris, and other deleterious material at the time of final acceptance.

G. **Cleaning Existing Drainage Structures and Leads.** Before the Contractor starts work, the Engineer will determine the condition and identify the areas on the project that require cleaning of existing drainage structures and leads.

First, clean the downstream drainage structure nearest the trunk sewer and place a temporary bulkhead so the trunk sewer remains clear. Clean upstream drainage structures and leads only after cleaning and bulkheading the downstream drainage structure.

Clean the drainage structures and leads of sand, silt, and debris and prevent further contamination of the leads.

Dispose of the waste generated from the drainage structure or drainage structure lead cleanout operation using either Disposal Alternative A or Disposal Alternative B in accordance with this subsection.

If the Contractor suspects the waste generated is non-hazardous contaminated material or hazardous contaminated material, notify the Engineer. If testing shows the material is a hazardous waste as defined in Part 111, Hazardous Waste Management, of the Natural Resources and Environmental Protection Act (Michigan Compiled Laws [MCL] 324.11101 et seq.), immediately notify the Engineer.

1. **Disposal Alternative A**

   a. **Solid Waste Phase.** Solid waste disposal rules require that the waste have no releasable liquids. Dispose of the solid waste at a Type II landfill. The landfill may require testing before accepting the waste. Provide disposal documentation from the Type II landfill to the Engineer.

   b. **Liquid Waste Phase.** Dispose of the liquid waste using one of the following options:

      Option 1 – Evaporate the liquid waste by use of drying beds, decanting stations, or similar systems that contain the solids during evaporation.

      Option 2 – Place liquid waste in a sanitary sewer system with the sanitary sewer owner's approval. Provide a copy of the owner's approval to the Engineer.

      Option 3 – Pump the majority of clear liquid from the drainage structure and leads without disturbing the solids. Discharge the clear liquid to:

      i. A sanitary sewer or combined sanitary and storm system with the sewer owner's approval;

      ii. The curb and gutter such that it re-enters and is completely contained within the storm sewer system and does not directly discharge into the waters of the state; or

      iii. An area of undisturbed, well-vegetated ground at a rate that does not result in excessive ponding, runoff, or soil erosion.

      Dispose of the remaining solid and liquid phase as waste using Disposal Alternative A, either Option 1 or Option 2, or Disposal Alternative B.

2. **Disposal Alternative B.** Use a Licensed Liquid Industrial Waste Hauler to transport the waste generated and dispose of it in accordance with Part 121, Liquid Industrial By-Products, of the Natural Resources and Environmental Protection Act (MCL 324.12101 et seq.). Provide the Engineer with a copy of the transport manifest.

403.04. MEASUREMENT AND PAYMENT

A. **Drainage Structures Excluding Drop Inlets.** The Engineer will measure the depth of drainage structures, with the exception of drop inlets, from the top of the masonry to the top of the concrete footing.

The unit price for **Dr Structure** of the diameter required includes the cost of concrete footing and no greater than 8 feet of the drainage structure depth. The unit price for **Dr Structure** includes the cost of temporary or final grade adjustments of the structure.

The unit price for **Dr Structure, Add Depth, 8 foot to 15 foot** of the diameter required includes the cost of drainage structure portions greater than 8 feet deep but no greater than 15 feet deep.

The unit price for **Dr Structure, Add Depth, more than 15 foot** of the diameter required includes the cost of drainage structure portions greater than 15 feet deep.

The unit price for new structures includes the cost of cleaning new drainage structures.

B. **Drop Inlets.** The Engineer will measure drop inlets as units, of the type required, regardless of depth.

The Department will pay separately for pipe leading from the drop inlet to a sewer or catch basin. The cost of pipe from drop inlets, Type 1, is included in the unit price for related sewer pay items in accordance with subsection 402.04. The cost of pipe from drop inlets, Type 2, as shown in the special detail, is included in the unit price for the related sewer pay item.

The Department will pay for a sewer tap or drainage structure tap in accordance with subsection 402.04 only if tapping the sewer or encased sewer into an existing drainage system is required.

C. **Manhole Base and Riser.** The Engineer will measure **Mh Riser** vertically from above the collar of the **Mh, Precast Tee** or above the **Mh Base** to the top of the riser.

The unit price for **Mh Base, Type 1** includes the cost of cutting access holes in the sewer.

If the Contractor uses **Mh Base, Type 1** in place of **Mh, Precast Tee,** and the contract does not include the pay item **Mh Base, Type 1**, the unit price for **Mh, Precast Tee** includes the cost of installing a Type 1 manhole base.

D. **Drainage Structure Covers.** When new covers are placed on existing structures, the Engineer will measure and the Department will pay for **Dr Structure Cover, Adj, Case** in addition to the new cover.

The unit price for **Dr Structure Cover, Adj, Case 1** includes the cost of the following:

1. Sawcutting existing pavement, curb, and curb and gutter;
2. Adjusting the cover up or down no greater than 6 inches; and

3. Removing and replacing pavement adjacent to the adjusted cover in accordance with the *MDOT Standard Plan R-37* series.

The Department will pay separately for removing and replacing curb and gutter adjacent to the adjusted structure.

The Department will pay only for **Dr Structure Cover, Adj, Case 2** for structure adjustments located outside existing pavement, curb, and curb and gutter.

The unit price for **Dr Structure Cover, Adj** of the case required includes the cost of repairs for uniform contact of temporary steel plate to the top of structures.

The Engineer will measure **Dr Structure, Adj, Add Depth** of the required diameter and depth beginning 6 inches from the level of the existing structure, in the direction of adjustment, to the limit of the additional adjustment depth. If the contract includes a pay item for **Dr Structure, Adj, Add Depth,** the contract will also include a pay item for **Dr Structure**

Cover, Adj of the case required. The unit price for **Dr Structure, Adj, Add Depth** includes the cost of drainage structure taps within the limits of the adjustment.

The Department will pay for drainage structure taps outside the limits of the adjustment as **Dr Structure, Tap**. The Department will pay for taps to existing sewers as **Sewer Tap** of the size required, in accordance with subsection 402.04.

E. **Drainage Structure, Temporary Lowering.** The unit price for **Dr Structure, Temp Lowering** includes the cost of the following:

1. Match marking;
2. Removing, salvaging, and transporting castings to and from the site;
3. Storing the existing structure castings;
4. Plating the structure;
5. HMA patching; and
6. Removing the plate and HMA patching materials for final adjustment.

The Department will pay separately for the final adjustments to drainage structures. The unit price for **Dr Structure Cover, Adjust, Case 1** includes the cost of removing pavement to lower the structure.

The cost of repairs is included in the unit price for the related drainage structure adjustment pay item.

F. **Cleaning Existing Drainage Structures and Leads.** The unit price for **Dr Structure, Cleaning** includes the cost of testing for disposal, hauling, and disposing of generated waste.

The unit price for **Dr Structure Lead, Cleaning** of the size required includes temporary bulkheads and the cost of testing for disposal, hauling, and disposing of generated waste.

The cost for cleaning out existing sewers, plugged by Contractor operations, is included in related pay items.

If not included in the contract, the Department will pay for disposal of non-hazardous contaminated material and hazardous contaminated material in accordance with subsection 109.05.

G. **Connect to Existing Structures.** All connections to existing structures by new drainage pipes, underdrains, or electrical lines shall be measured per each and include coring, connection of pipe/conduit, backflow prevention (if needed), reconstruction of flow benching, and concrete mortar.

403.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-403.05.01	Non-Aircraft Rated Dr Structure, 24 in dia	Each (EA)
MDOT-403.05.02	Aircraft Rated Dr Structure, 48 in dia - Bid Alt 1	Each (EA)
MDOT-403.05.03	Aircraft Rated Dr Structure, 24 in dia - Bid Alt 1	Each (EA)
MDOT-403.05.04	Non-Aircraft Rated Dr Structure Cover, Type D	Each (EA)
MDOT-403.05.05	Aircraft Rated Dr Structure Cover, Type D - Bid Alt 1	Each (EA)
MDOT-403.05.06	Aircraft Rated Dr Structure Cover, Type Q - Bid Alt 1	Each (EA)
MDOT-403.05.07	Dr Structure, Cover Adj, Case 2 (0”-6”)	Each (EA)
MDOT-403.05.08	Dr Structure, Adj, Add Depth (>6")	Each (EA)
MDOT-403.05.09	Connect to Existing Structures	Each (EA)
MDOT-403.05.10	Connect to Existing Structures - Bid Alt 1	Each (EA)

END OF ITEM MDOT-403

Item MDOT-404 Underdrains

404.01 DESCRIPTION

This work consists of constructing and installing underdrains, foundation underdrains, and underdrain outlets.

404.02 MATERIALS

Provide materials in accordance with the following sections:

Granular Material Class II AA 902

Open-Graded Aggregate 34R 902

End Sections…….....909

Pipe for Underdrains 909

Underdrain Outlets.....909

Drainage Marker Posts.....909

Sod…… 917

Topsoil……. 917

Concrete, Grade 3000….....1004

Mortar, Type R-2 1005

Controlled Low-Strength Material P-153

A. **Pipe.** Provide geotextile-wrapped perforated pipe and tubing for underdrains, except if using with open-graded backfill material. Provide non-perforated pipe and tubing not wrapped with geotextile for underdrain outlets. Provide the following slot or hole size and water inlet area for pipe if using steel furnace slag for open-graded drainage course.

Table 404-1:

Pipe Opening Sizes for Steel Furnace Slag Open-Graded Drainage Course

Opening Type	Size
Slot width	1/16 – ⅛ inch
Hole diameter	⅛ – 3/16 inch
Water inlet area (min)	2 in²/ft of tubing

B. **Aggregate for Trench Backfill.** Provide open-graded aggregate 34R to backfill the trench for open-graded underdrain. Provide granular material Class II AA as backfill for other underdrains and underdrain outlets.

C. **Outlet Endings.** Provide a concrete ring, steel end section, or concrete end section for the outlet ending.

404.03 CONSTRUCTION

The plans will show the locations for underdrain and underdrain outlets or will establish a miscellaneous quantity of pipe for use on the project. The plans will show, or the engineer will determine, the line and grade of the Underdrain. Place the outlets at the intervals shown on the plans and ensure that the outlets drain.

A. **Trench Excavation.** Excavate underdrain trenches using a wheel or chain trencher or other trenching method approved by the engineer. Grade trench bottoms to the shape of the underdrain pipe. Line trenches for open-graded underdrains with geotextile blanket as required.

B. **Laying Underdrains.** Place the underdrains to the line and grade shown on the plans or established by the engineer. Ensure a firm bearing along the length of the pipe. Place compatible end caps on the upgrade ends of the underdrain pipes. Remove and re-lay damaged or displaced pipe.

C. **Connections.** Select fittings and connection methods in accordance with the underdrain system manufacturer's recommendations to prevent pipe separation.

Do not penetrate the inside diameter of the pipe with the self-tapping screws by more than ⅛ inch. Wrap fittings with geotextile blanket and seal the geotextile to the outlet pipe with waterproof tape.

D. **Backfill and Compaction.** Place backfill in trenches after the engineer approves the underdrain line and grade.

1. **Foundation, Bank, Subbase And Subgrade Underdrains, and Underdrain Outlets.** Backfill using granular material Class IIAA.

   Place the granular material around the pipe to cover the drain with at least 12 inches of material. Place the remaining backfill in layers no greater than 12 inches. Compact the trench backfill material within the influence of the roadbed to 95% of the maximum unit weight. Compact trenches outside the roadbed as directed by the engineer.

   If the contract calls for open-graded subgrade underdrain and open-graded bank underdrain, place the open-graded aggregate 34r as shown on the plans for open-graded underdrains.

2. **Open-Graded Underdrains.** Backfill pipe with open-graded aggregate 34r. After placing the backfill, compact the backfill and the surrounding grade material with a vibrating plate compactor. Begin compaction along the shoulder side of the underdrain and progress toward the pavement. Do not operate the compactor directly above the underdrain.

   Maintain the exposed underdrain and backfill to prevent contamination.

Remove and replace contaminated backfill material as determined by the engineer at no additional cost to the department. Clear obstructed underdrain as determined by the engineer at no additional cost to the department.

E. **Underdrain Outlet.** Lay underdrain outlets on at least a 4% grade and install the underdrain outlet at least 4 inches above the receiving ditch or sewer flow line. The engineer may waive the percent grade requirement if determining that it is not practical to meet both the percent grade and the outlet elevation requirements. Connect underdrain outlet pipe to the underdrain in accordance with *MDOT Standard Plan R-80 series*. The use of wyes, tees, or other similar fittings is not acceptable. Do not backfill the outlet trench until approved by the engineer. Install underdrain outlets within 48 hours of installing adjoining longitudinal underdrains. Mark and maintain the outlets until final acceptance of the work.

F. **Outlet Endings.** Place the outlet endings as shown on the plans or as directed by the engineer. Install drainage marker posts in accordance with subsection 401.03.f.

Mark the locations of outlet endings on the adjacent shoulder if installing underdrains in conjunction with constructing or resurfacing concrete or HMA shoulders. Mark locations with a ½-inch-deep, 4- by 6-inch depression. Place the long edge of the depression perpendicular to the edge of the shoulder. The engineer may approve the following alternative methods of marking locations:

1. Stencil markers in concrete shoulders after texturing.
2. Form markers in HMA shoulders during finish rolling. Obtain the engineer's approval of forming method prior to beginning work.

G. **Cleanout.** Ensure that installed underdrains and outlets are free of silt, debris, and other deleterious material at the time of final acceptance.

H. **Video Inspection Of Underdrains.** The department will perform video inspection of underdrains, underdrain outlets, and outlet endings after installation is complete.

The department will perform video inspections of open-graded underdrains after the mainline pavement placement is complete but before shoulder paving.

Submit a log detailing the locations of the drain outlets installed on the project to the engineer. In the drain outlet log, include locations of bank drain outlets, subgrade and subbase underdrain outlets, and open-graded underdrain outlets.

1. **Deficiencies.** Corrective action, including excavating and repairing or removing and replacing the underdrain or underdrain outlets, will be required if video inspection reveals any of the following deficiencies:

    A. Crushed pipe;

    B. Separated joints,

    C. Plugged underdrain or underdrain outlet pipe;

    D. Standing water greater than half the pipe diameter for greater than 25 feet; or

E. Other defects in materials or workmanship as determined by the engineer.

2. **Corrective Action.** Obtain approval from the engineer for the repair or removal and replacement method before beginning corrective action. Complete corrective action within 10 working days of video inspection completion or other date as approved by the engineer.

3. Complete the following corrective action at no additional cost to the department:

A. Excavate;

B. Repair or remove and replace defective underdrain, underdrain outlets, and outlet endings;

C. Backfill excavated areas;

D. Replace and compact overlying fill, aggregate base separator course, and open-graded drainage course materials;

E. Replace geotextile separator as required; and

F. Replace finished shoulder or pavement material in accordance with the contract.

I. **Underdrain Cleanout.** Place the underdrain cleanouts as shown on the plans or as directed by the Engineer.

404.04 MEASUREMENT AND PAYMENT

A. **General.** The engineer will measure underdrains in place.

The engineer will measure underdrain outlet, of the size required, in place from the underdrain to the center of a drainage structure or from the underdrain to the end of the outlet pipe. In addition to work specified for individual pay items, the unit prices for the relevant underdrain and underdrain outlet pay items include the cost of the following:

1. Excavating the trench;

2. Providing and placing the pipe and fittings;

3. Providing, placing, and compacting the backfill material; and

4. Disposing of surplus material excavated from the trench.

The department will not consider claims for additional compensation for time required to repair or remove and replace deficient underdrain, underdrain outlets, and overlying materials.

B. **Subgrade, Bank, Foundation, and Subbase Underdrains.** Not Used.

C. **Underdrain, Pipe, Open-Graded.** The unit price for underdrain, pipe, open-graded of the size required includes the cost of providing and lining the trench with geotextile blanket.

D. **Underdrain Outlet.** Not Used.

E. **Underdrain, Outlet Ending.** Not Used.

F. **Underdrain, Cleanout.** The unit price for Underdrain, Cleanouts includes the cost of the following:

1. Excavating the area of the cleanout;
2. Backfilling and placing of the materials;
3. Furnishing and installation of such specials and connections to pipes and other structures as may be required to complete the item as shown on the plans;
4. Flowable concrete per P-153 and structural concrete per MDOT-1004.

404.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-404.05.01	Underdrain, Pipe, Open-Graded, 6 inch	Linear Foot (LF)
MDOT-404.05.02	Underdrain, Pipe, Open-Graded, 4 inch	Linear Foot (LF)
MDOT-404.05.03	Underdrain, Cleanout	Each (EA)
MDOT-404.05.04	Underdrain, Pipe, Open-Graded, 4 inch - Bid Alt 1	Linear Foot (LF)
MDOT-404.05.05	Underdrain, Cleanout - Bid Alt 1	Each (EA)

END OF ITEM MDOT-404

Item MDOT-501 Plant-Produced Hot Mix Asphalt

501.01 DESCRIPTION

This work consists of providing and placing hot mix asphalt (HMA) mix using Superpave mixture design methods.

A. Definitions

Binder Content. Percent by weight of asphalt cement in the total mixture.

Broken Aggregate. Cracked aggregate caused by construction operations.

Bulk Specific Gravity of Aggregate (Gsb). Ratio of the oven dry weight in air of a unit volume of an aggregate at a stated temperature to the weight of an equal volume of water at a stated temperature.

Crack. Visible fissure of varying length and orientation in the HMA, partially or completely through at least one course.

Effective Specific Gravity (Gse). Ratio of the oven dry weight in air of a unit volume of an aggregate (excluding voids permeable to asphalt) at a stated temperature to the weight of an equal volume of water at a stated temperature.

Flushing. Shiny or reflective condition, tacky to the touch, appearing on the HMA surface when asphalt binder collects in the voids at high pavement temperatures.

HMA Mix Design. Selection and proportioning of aggregates, mineral filler, reclaimed asphalt pavement (RAP), and asphalt binder to meet the required mix design criteria.

HMA Segregation. Areas of HMA pavement exhibiting non-uniform distribution of coarse and fine aggregate particles, visually or otherwise identifiable.

Job Mix Formula (JMF). HMA mix for a specific project, including adjustments to optimize the field application.

Lot. A lot is made up of a discrete tonnage of one mixture. A lot typically has five sublots (see definition of “sublot”).

Maximum Specific Gravity of Mixture (Gmm). Ratio of the weight in air of a unit volume of an uncompacted HMA at a stated temperature to the weight of an equal volume of water at a stated temperature.

Pavement. Completed HMA placement, including layers on driving lanes and shoulders.

Pavement Edge. Extremity boundaries of the pavement.

Roller Cracking. High-density surface map-cracking that appears immediately after rolling.

Rutting. Depression or displacement of the HMA surface that occurs in a longitudinal direction or a localized area.

Quality Assurance (QA). All activities dealing with acceptance of the product, including but not limited to materials sampling, testing, construction inspection, and review of Contractor quality control (QC) documentation. The Engineer’s HMA QA procedures are contained in MDOT’s HMA Production Manual and MDOT’s HMA QA Plan.

Quality Control (QC). All activities dealing with process control to ensure quality, including but not limited to training, materials sampling, testing, project oversight, and documentation.

For example, the Contractor's HMA QC procedures are contained in the Contractor's HMA QC Plan.

Sublot. Portion of a lot or an individual sample that is represented by a complete set of QA tests. Sublots are approximately equal in size at 1,000 tons. The Contractor and the Engineer may agree to reduce the typical 1,000-ton sublots based on project staging or other project conditions.

Target Value. JMF parameter value that may be adjusted, if approved by the Engineer, to account for changes in the physical properties of the mixture.

Temporary Pavement. Roadway and appurtenances constructed to help the movement of highway and pedestrian traffic around a construction operation that will be removed upon completion of the project.

Unlimited Daily HMA Production. Unrestricted daily HMA production tonnage.

Voids in Mineral Aggregate (VMA). Volume of void space between the aggregate particles of a compacted paving mixture that includes the air voids and the asphalt binder not absorbed into the aggregate, expressed as a percentage of the total volume of mixture.

501.02 MATERIALS

Provide materials in accordance with the following sections:

Superpave HMA Mixtures…….902

Superpave Aggregates……902

Mineral Filler, 3MF……902

Anti-Foaming Agent……904

Asphalt Binders……904

Bond Coat, SS-1h, CSS-1h, LTBC-1, LTBC-2……...904

Plant-produced HMA consists of asphalt binder, aggregates, mineral filler, and other additives.

Provide release agents that do not harm the HMA mixture. Do not use fuel oil or other distillate derivatives.

Provide the HMA mix type and the performance grade of asphalt binder as required by the contract.

Provide blended aggregates for HMA top course mixtures, except top courses for shoulders, bike paths, temporary roads, and parking areas, meeting the required Aggregate Wear Index (AWI).

A. Composition of HMA Mixtures

1. **Mix Design.** Develop an HMA mix design in accordance with the HMA Production Manual and submit to the Department. The Department will evaluate the design in accordance with Section 1 of the HMA Production Manual, "Procedures for HMA Mix Design Processing."

   Provide written certification that the materials in the mix design are from the same source and meet the material properties in the mix design or the Department-approved JMF. Make all JMF adjustments in accordance with the HMA Production Manual.

Provide combined aggregate blends meeting the properties specified in section 902. Provide a mix design that meets the requirements in Table 501-1, Table 501-2, and Table 501-3.

For mix design purposes, top and leveling courses are the mix layers within 4 inches of the surface. The base course consists of the layers below 4 inches from the surface. For mix layers within the 4-inch threshold, if less than 25% of the mix layer is within 4 inches of the surface, the mix layer is a base course.

Table 501-1: Superpave Mix Design Criteria

Design Parameter	Mix Number			
	5	4	3	2
Percent of maximum specific gravity (%G_{mm}) at the design number of gyrations (N_d)	96.0%[(a)]			
%G_{mm} at the initial number of gyrations (N_i)	See Table 501-3			
%G_{mm} at the maximum number of gyrations (N_m)	≤98.0%			
Voids in mineral aggregate (VMA) min % at N_d (based on aggregate bulk specific gravity (G_{sb}))	15.00	14.00	13.00	12.00
Voids filled with asphalt (VFA) at N_d	See Table 501-2[(b)]			
Fines to effective asphalt binder ratio (P_{No200}/P_{be})	0.6–1.2			
Tensile strength ratio (TSR)	80% min			

(a) Unless noted otherwise on the plans, design all mixtures to 96.0% of maximum specific gravity (%Gmm) at the design number of gyrations (Nd). During field production, increase percent of maximum specific gravity (%Gmm) at the design number of gyrations (Nd) to 97.0%. Use liquid asphalt cement for regression of mixes unless otherwise noted on plans.

(b) For regressed mixtures the maximum criteria limits do not apply.

Table 501-2:
VFA Minimum and Maximum Criteria

Estimated Traffic (million ESAL)	Mix Type	Top and Leveling Courses	Base Course
≤0.3	EL	70–80%	70–80%
>0.3 – ≤3.0	EML	65–78%	65–78%
>3.0 – ≤30	EMH	65–78%[(a)]	65–75%
>30 – ≤100	EH	65–78%[(a)]	65–75%

ESAL = equivalent single-axle load
(a) The specified VFA range for mix Number 5 is 73–76%.

Table 501-3:
Superpave Gyratory Compactor Compaction Criteria

Estimated Traffic (million ESAL)	Mix Type	%G_{mm} at (N_i)	Number of Gyrations[(a)]		
			N_i	N_d	N_m
≤0.3	EL	≤91.5%	7	50	75
>0.3 – ≤3.0	EML	≤90.5%	7	75	115
>3.0 – ≤30	EMH	≤89.0%	8	100	160
>30 – ≤100	EH	≤89.0%	9	125	205

ESAL = equivalent single-axle load

(a) Compact mix specimens fabricated in the Superpave gyratory compactor (SGC) to N_d. Use height data provided by the SGC to calculate volumetric properties at N_i. Compact mix specimens at optimum P_b (percent asphalt binder content) to verify N_m for mix design specimens only.

If high-stress HMA is shown on the plans, provide the same mix designation (5EML, 5EMH, 4EML, 4EMH, etc.) as required for the mainline top and leveling courses, except change the performance-graded (PG) binder as shown on the HMA application table.

2. **Recycled Mixtures.** Recycled asphalt pavement (RAP) may be substituted for a portion of the new material required to produce the HMA mixture. Design and produce the mix to meet the criteria in this subsection and the contract.

    a. **Stockpile Requirements.** Process RAP to the size required for the specified HMA mix. Ensure the stockpile contains enough material to produce the recycled mixtures the Engineer approves for the project. If the RAP stockpile is not sufficient to produce recycled mix quantities required for the project, provide an Engineer-approved mix design without RAP at the same unit price.

    Provide documentation of testing (one test per 1000 tons, minimum of three tests) and accumulated tonnage in the stockpile to the MDOT laboratory. The tonnage may be estimated. The Department will begin evaluating the mix design after receipt of the documentation.

    b. **Mix Design.** Submit required documentation for recycled mix designs in accordance with Section 1 of the HMA Production Manual, “Procedures for HMA Mix Design Processing.”

B. **HMA Plant Certification.** Ensure HMA plants are certified by the Department at least 5 days before mix production begins. The Engineer will certify HMA facilities in accordance with Section 2 of MDOT’s HMA Production Manual, “Certification Procedure of HMA Plants.” Post a seal of certification in the plant control office.

C. **HMA Production.** Submit an approved mix design for the mix required to the Engineer at least 4 days before production begins.

Provide even heating of the mass of asphalt binders and maintain heat control. Heat asphalt binders to the temperature required for the type of binder. Do not exceed the maximum temperature specified in Table 904-8 for asphalt binder and HMA. The Department will reject asphalt binder and mix if the temperature exceeds the maximum specified in Table 904-8. The Department will reject contaminated asphalt binder.

Stockpile aggregates at the facility in a manner that prevents segregation. Dry aggregates to a moisture content that will ensure an appropriately coated HMA mix. For batch and continuous plants, the Department will reject aggregates in the hot bins that contain sufficient moisture to cause foaming or a water-saturated mixture. Remove rejected materials from the bins.

Place uniform gradations of aggregates in the cold feed system. If providing a blend of aggregates for the mix by combining aggregates from at least two cold feed bins, ensure that the blend meets the combined gradation (from JMF) QC tolerances.

The use of at least one hot aggregate bin to proportion aggregates to meet the JMF tolerances is allowed if the cold feed requirements are met.

501.03 CONSTRUCTION

A. **Equipment.** Provide equipment in accordance with section 107, capable of producing pavement that meets the requirements of this section.

1. **Cold-Milling Machines.** Provide equipment that consistently removes the HMA surface, in one or more passes, to the required grade and cross section, and produces a uniformly textured surface. Provide machines equipped with the following:

    a. Provide a cold-milling machine that has sufficient power, traction, and stability to maintain an accurate depth of cut. Maintain the propulsion and guidance system of the milling machine in such condition that the milling machine may be operated to straight and true lines;

    b. Provide a cold-milling machine capable of operating using minimum 30-foot automatic grade controls (contact or non-contact) averaging system or other approved grade control systems and capable of transverse slope control. Describe the use of such controls in the Contractor's Cold-Milling Quality Control Plan; and

    c. Provide a cold-milling machine capable of picking up the removed material in a single operation. A self-loading conveyor will be an integral part of the milling machine. Windrows are not allowed.

2. **Hauling Equipment.** Ensure that transport trucks are equipped to protect the mix from the weather and retard the loss of heat. Equip transport trucks and trailers with a working backup alarm.

3. **Pressure Distributor.** Provide a pressure distributor in accordance with subsection 505.03.A.1.

4. **Pavers.** Equip each paver with a full-width vibratory or tamper bar screed capable of spreading and finishing HMA to the required cross section and grade. Use a paver that produces a uniformly finished surface, free of tears, other blemishes, and measurable segregation.

Equip the paver to provide a uniform head of material ahead of the screed. Install reverse pitch augers or paddles inside the ends of the auger shafts to force the mix to the center of the main screed.

Ensure that extensions added to the main screed provide the same vibrating or tamping action and heating capabilities as the main screed. Adjust extensions to the main screed so, after breakdown rolling, no longitudinal marks remain on the surface. Equip in-line screed extensions with a continuation of the automatically controlled spreading augers to within 12 inches of the outside edge. Follow the manufacturer's recommendations for other screed extensions.

Except for the paving operations listed in subsection 501.03.F.1.a through subsection 501.03.F.1.d, equip pavers with an automatically controlled and activated screed with grade reference and transverse slope control. Use an Engineer-approved grade referencing attachment, at least 30 feet long for lower courses and the first pass of the top course. Ensure that the Engineer approves alternate grade referencing attachments before use.

After placing the first pass of the top course, the Contractor may, with prior approval from the Engineer, substitute a joint matcher, a grade referencing attachment at least 10 feet long, or other grade referencing equipment for constructing adjacent passes of the top course.

5. Rollers

a. **Steel-Wheeled Rollers.** Provide self-propelled vibratory steel-wheeled rollers, static tandem rollers, or self-propelled static three-wheeled rollers. Provide a steering device that allows the roller to follow the established alignment. Equip rollers with wheel sprinklers and scrapers. Provide smooth roller wheels, free of openings or projections that will mar the pavement surface.

   Provide vibratory rollers with an automatic shutoff to deactivate the vibrators if the roller speed decreases below ½ mph. Provide rollers that operate in accordance with the manufacturer's recommended speed, impacts per foot, and vibration amplitude for the thickness of HMA mix.

b. **Pneumatic-Tired Rollers.** Provide self-propelled pneumatic-tired rollers. Equip rollers with at least seven wheels spaced on two axles so the rear group of tires does not follow in the tracks of the forward group, providing at least ½-inch tire path overlap. Provide smooth tires capable of being inflated to the pressure recommended by the roller or tire manufacturer. Equip the rollers with a mechanism that can smoothly reverse the motion of the roller.

   Equip the rollers with wheel scrapers and skirting to enclose the wheels to within 3 inches of the pavement surface. Use a release agent to prevent material from sticking to the tires and being deposited on the top course pavement during rolling.

c. **Combination Rollers.** The Contractor may use combination pneumatic-tired and steel-wheeled rollers manufactured specifically for HMA compaction, if equipped with the required sprinklers and scrapers.

6. **Spreaders.** Use self-propelled spreaders capable of pushing the hauling units. Ensure that spreaders can maintain the required width, depth, and slope, without causing segregation.

7. **Material Transfer Device.** When a material transfer device (MTD) is required, it must be capable of delivering HMA mix from the truck transport to the paver hopper to ensure constant paver speed, remixing HMA material using manufacturer's developed technology, and depositing material in the paver hopper. Provide a paver hopper insert with at least a 10-ton capacity in the paver and keep at least two-thirds full of mix during paving. A windrow pickup machine does not satisfy the requirements for an MTD.

8. **Compressed Air System.** If a compressed air system is required for cleaning pavement, equip the air compressor with a moisture separator to remove oil and water from the air supply. Provide a compressor capable of producing at least 100 psi and continuous 150 cfm airflow.

9. **Miscellaneous Equipment.** Provide a straightedge, at least 10 feet long, and other tools to finish the work.

10. **Lights on Equipment.** If maintaining traffic on HMA construction, equip equipment within the project, including cold-milling machines, distributors, and rollers, with at least one Department-approved flashing, rotating, or oscillating amber light. Equip pavers with at least one light on each side. Mount the lights so the warning signal is visible to traffic in every direction. Operate the lights while work is in progress. Ensure that hauling units activate four-way flashers on the project.

B. **Preparation of Base.** Provide subgrade, subbase, aggregate base course, crushed and shaped base, or rubblized base in accordance with the relevant sections of Division 2 and Division 3, before HMA placement.

C. **Preparation of Existing Pavement.** Prepare the existing surface as required to construct HMA pavements, shoulders, and approaches.

1. **Drainage Structures, Monument Boxes, and Water Shutoffs.** Adjust, temporarily lower, or both, catch basins, manhole covers, monument boxes, and water shutoffs in accordance with subsection 403.03.A. Meet the smoothness requirements required in subsection 501.03.H.

2. **Cleaning Pavement.** Using methods approved by the Engineer, clean dirt and debris from the pavement surface and paved shoulders before placing HMA. Remove loose material from joints and cracks using compressed air.

   If the Engineer determines the compressed air system will not remove deleterious material, remove loose material by a hand or mechanical method, as approved by the Engineer. The Department will pay for removal of material by hand or mechanical methods in accordance with subsection 501.04.E.

Do not place HMA until the Engineer inspects and approves the condition of the existing pavement.

3. **Removing Existing Pavement for Butt Joints.** If a butt joint is required, remove the existing surface to the thickness of the proposed overlay for the full width of the joint. Uniformly taper the removal to the original surface over at least 35 feet.

4. **Edge Trimming.** For required removal of HMA shoulder material or no greater than 1 foot width of HMA pavement, cut the HMA material full depth along the pavement edge or removal line to prevent tearing the pavement surface. Cut joints, where the completed surface will be exposed, with a saw, cold-milling machine, or other methods approved by the Engineer. Cut joints, where the completed surface will be covered by HMA mix, with a coulter wheel, saw, cold-milling machine, or other method approved by the Engineer.

5. **Cold-Milling HMA Surfaces.** Before milling existing pavement, obtain a Department-approved mix design in accordance with subsection 501.02.A, and ensure the availability of HMA mix quantities to cover milled surfaces. Do not maintain traffic on the milled surface unless specified in the contract or approved by the Engineer.

   Cold-Milling QC Plan and Cold-Milling Operations Plan. Prior to beginning milling operations, submit a Cold-Milling QC Plan and a Cold-Milling Operations Plan to the Engineer for approval.

   a. Include, as a minimum, the following items in the Cold-Milling QC Plan:

      i. The schedule for replacing the cutting teeth;

      ii. The daily preventive maintenance schedule and checklist; Proposed use of automatic grade controls;

      iii. The surface testing schedule for smoothness; The process for filling distressed areas;

      iv. The schedule for testing macrotexture of the milled surface;

      v. Corrective procedures if the milled surface does not meet the minimum macrotexture specification;

      vi. Corrective procedures if the milled surface does not meet the minimum transverse or longitudinal surface finish when measured with a 10-foot straightedge;

      vii. The methods for longitudinal control guidance (painted string line or measure offs); and

      viii. Contact information for on-site contractor personnel responsible for the work and authorized to adjust the QC plan.

   b. Include, as a minimum, the following specific items in the Cold-Milling Operations Plan:

      i. Number, types, and sizes of mill machines to be used;

ii. Width and location of each mill machine pass;

iii. Number and types of brooms and or vacuum trucks to be used and their locations with respect to the mill machine;

iv. Proposed method for mill machine and wedging around existing structures such as manholes, valve boxes, and inlets;

v. Longitudinal and transverse typical sections for tie-ins at the end of the day;

vi. If requested by the Engineer, a plan sheet showing the milling passes; and

vii. Names of macro-texture testing personnel and sequencing of testing (minimum of three tests daily that are representative of the day's milling).

Remove the HMA surface to the depth, width, grade, and cross section shown on the plans. Backfill and compact depressions resulting from removal of material below the specified grade, in accordance with subsection 501.03.C.9.

If the milling machine discovers buried structures within the specified grade, such as valve boxes, manholes, or railroad tracks that are not identified on the plans, the Department will pay for all associated costs, as extra work, in accordance with subsection 103.02.

Immediately after cold-milling, clean the surface. Dispose of removed material in accordance with subsection 104.07.D and subsection 204.03.

Mill the existing pavement to the cross slope shown on the plans. Supply a 10-foot straightedge. Ensure that the finished surface does not vary longitudinally or transversely more than ¼ inch from a 10-foot straightedge. Ensure that the milled area is free from gouges, continuous grooves, and ridges and has a uniform texture. Ensure that the horizontal gouge in the vertical edge created from the milling operation is limited to a maximum width of inch. Adjust speed, drum speed, and/or teeth as necessary to meet the requirements of this specification. Ensure that the milling operation provides an acceptable surface texture by achieving a maximum mean texture depth of 0.108-inch thickness according to ASTM E965. Perform three random QA macro texture tests daily that are representative of the day's milling to maintain texture and verify conformance with the 0.108-inch thickness mean texture depth requirement. For projects with less than 3,000 square yards, a minimum of one random QA macro texture test per day is required. Perform tests as soon as practical behind the milling operations.

6. **Removing HMA Surface.** Except as specified in subsection 501.03.C.4, removing an HMA surface applies to removing HMA overlying a material designated for removal or that is required to remain in place.

Cut joints, exposed in the completed surface, with a saw or cold-milling machine. Cut joints, covered by HMA mix, with a coulter wheel, saw, or cold-milling machine. Obtain the Engineer's approval of alternate methods for cutting joints.

When removing HMA overlying a base course that is to remain in place, cut the edges of the surface requiring removal along straight lines for the full depth of the HMA surface.

When removing HMA by cold-milling, the Engineer may direct removal to be less than the full depth of HMA surface.

7. **Removing HMA Patches.** Remove patches that may compromise the performance of the overlay.

8. **Joint and Crack Cleanout.** If the plans show joint and crack cleanout, use mechanical or hand methods to remove joint sealants to at least 1 inch deep. Remove vegetation, dirt, and debris that cannot be removed using the methods specified in subsection 501.03.C.2 from transverse and longitudinal joints and cracks. Use hand patching to fill cleaned joints and cracks at least 1 inch wide.

9. **Hand Patching.** If the contract requires hand patching, fill holes, depressions, joints, and cracks in the existing pavement and replace existing patches. Compact the hand patching material in no greater than 3-inch layers to the adjacent pavement surface grade using a machine vibrator or Department-approved roller. Use top course or other Engineer-approved mix for hand patching material.

10. **Repairing Pavement Joints and Cracks.** Repair joints and cracks as required.

D. **Bond Coat.** Uniformly apply the bond coat and provide complete coverage to a clean, dry, surface with a pressure distributor. Obtain the approval of the Engineer for the application rate after work begins. Application rate must be within a range of 0.05 to 0.15 gallons per square yard. Apply the bond coat ahead of the paving operation to allow the bond coat to cure before placing HMA.

Do not leave pools of bond coat on the surface and do not spray the bond coat on adjacent pavement surfaces. Apply the bond coat to each HMA layer and to the vertical edge of the adjacent pavement before placing subsequent layers.

E. **Transportation of Mixtures.** Weigh each load of HMA, accepted by the Department, to the nearest 20 pounds on an approved scale with an automatic printout system. Provide a scale and printout system for platform and suspended scales in accordance with subsection 109.01.B.6. Provide a ticket to the Engineer with each load.

Apply a release agent, in accordance with subsection 501.02, to hauling units. Loads with excessive amounts of release agent will be rejected. Do not place crusted HMA in the paver.

The Department will reject loads, immediately prior to placement, with a temperature either below 250°F (225°F when using a warm mix chemical additive) or greater than 20°F from the recommended maximum mixing temperature specified by the binder producer.

F. Placing HMA

1. General

Place HMA on a cured bond coat using pavers in accordance with subsection 501.03.A.4 unless placing mixtures for the following:

a. Variable width sections;

b. The first course of a base course mix on a subgrade or sand subbase;

c. Base course mixtures for shoulders and widening less than 10½ feet wide; or

d. Top and leveling course mixes for shoulders and widening less than 8 feet wide.

Place HMA mix in layers, and do not exceed the application rate. If the application rate for an HMA pavement exceeds the maximum rates specified in Table 501-4 and the edges are not confined, construct the pavement in at least two layers.

Table 501-4:
HMA Application Rates

Mix Number[(a)]	Course Application	Application Rate (lb/yd²), minimum – maximum[(b)]
2	Base	435–550
3	Base, leveling	330–410
4	Leveling, top	220–275
5	Top	165–220

(a) See Table 501-1 for the mix number design parameters.
(b) Minimum application rates do not apply to wedging courses.

Wedge with HMA to remove irregularities in the existing road surface. Place and compact HMA wedging to correct the foundation. Allow the wedging to cool enough to support construction equipment without causing visible distortion of the mat before placing subsequent wedging, base, leveling, or top course mixtures.

Place HMA mix to the slope and width shown on the plans. Place subsequent HMA course to align the vertical edge with the previous courses, without constructing a ledge. Correct ledges that result from placing material in excess of the width shown on the plans at no additional cost to the Department.

Place shoulder aggregate and compact flush after placement of each layer of HMA at the end of the paving day or place traffic control devices in accordance with subsection 812.03, at no additional cost to the Department. Complete final shaping and compaction of the shoulders after placing the top course of HMA.

If delays slow paving operations and the temperature of the mat immediately behind the screed falls below 200°F, stop paving and place a transverse construction joint. If the temperature of the mat falls below 190°F before initial breakdown rolling, remove and replace the mat at no additional cost to the Department.

If placing the uppermost leveling and top course, place the longitudinal joint to coincide with the planned painted lane lines.

If the temperature of the mat falls below 170°F before placing the adjacent mat, apply bond coat to the vertical edge of the mat.

If constructing the lanes with at least two pavers in echelon, match the depth of loose HMA from each paver at the longitudinal joints.

2. Joints in HMA Pavement

a. **Transverse Construction Joint.** If constructing a transverse construction joint, stop the paver and lift the screed before material falls below the auger shaft. Remove the paver and roll through the planned joint location. Cut a transverse vertical joint and remove excess HMA.

Place burlap, canvas, or paper as a bond breaker ahead of and against the vertical face. Place HMA against the bond breaker and taper from the new mat to the existing surface. Extend the temporary taper 5 feet for each inch of mat thickness, or as directed by the Engineer. Compact and cool the temporary taper before allowing traffic on the new surface. Remove the temporary taper before resuming paving.

b. **Feather Joint.** Transition the new mat to existing surfaces at the beginning and end of resurfacing sections and at intersections unless using butt joints. Transition the new mat to existing surfaces at a rate of 1 inch over 35 feet. Construct transitions on a cured bond coat applied at a rate of 0.10 gallon per square yard. After compaction, spray with bond coat, sand, and roll the first 3 feet of the joint and 1 foot of the existing surface.

c. **Vertical Longitudinal Joint.** When opening to traffic, plan the work to resurface adjacent lanes to within one load of the same ending point at the completion of paving operations each day. Construct a vertical joint to conform to the pavement cross section.

When compacting an unsupported (unconfined) edge of the mat, keep the roller from 3 to 6 inches inside the unsupported edge on the first pass; ensure that the roller overhangs the unsupported edge by 3 to 6 inches on the second pass.

When placing HMA in a lane adjoining a previously placed lane, place the mixture so that the strike-off shoe will produce an edge that is adjacent to or minimally overlaps the adjoining course. Compact the longitudinal joint by rolling from the hot side, keeping the edge of the roller approximately 6 inches to 8 inches inside the cold joint for the first pass. For the second pass of the roller, compact the joint from the hot side while overlapping the cold side by 6 to 8 inches.

d. **Tapered Overlapping Longitudinal Joint.** A tapered overlapping longitudinal joint may be used instead of a longitudinal vertical joint.

If using tapered overlapping longitudinal joints, resurfacing lanes within one load of the same point-of-ending at the completion of paving operations each day is not required. Pave adjacent lanes within 24 hours unless delayed by inclement weather or approved by the Engineer.

Construct the tapered overlapping longitudinal joint by tapering the HMA mat at a slope no greater than 1:12. Extend the tapered portion beyond the normal lane width.

Place a ½-inch to 1-inch notch at the top of the taper on paving courses.

Provide a uniform slope by constructing the tapered portion of the mat using a Department-approved strike-off device that will not restrict the main screed.

Apply bond coat to the surface of the taper before placing the adjacent lane.

3. **Placing HMA Shoulders.** Use a self-propelled mechanical paver or spreader to place HMA shoulders.

   If placing the top course on new shoulders, or placing leveling, or top course on existing HMA shoulders at least 8 feet wide, place the mix using a paver with an automatically controlled and activated screed and strike-off assembly and corresponding grade referencing equipment. Use grade-referencing equipment as directed by the Engineer.

   Stop shoulder paving at crossroad approaches, auxiliary lanes, commercial driveways, and ramps. Do not pave through these areas.

4. **Placing HMA Approaches.** Place HMA on driveway or crossroad approach foundations, as approved by the Engineer.

   Place approaches in layers no greater than the application rate. Do not stop mainline paving of lanes adjacent to the approach to pave the HMA approach.

5. **Safety Edge.** Construct the safety edge on the shoulders at locations shows on the plans. The finished shape of the safety edge will be in accordance with MDOT Standard Plan R-110 series. Ensure that the safety edge is constructed monolithically with the shoulder and is of the same material type. Prior to placing HMA shoulder overlays, prepare the existing shoulder material to provide a smooth and uniform paving surface. Excavate, trench, and/or shape the existing shoulder material so that the safety edge may be placed as required on the plans. Ensure that the existing material does not impede the paving equipment and placement of HMA. For new or reconstructed shoulders, prepare base materials in accordance with the plans.

   Use an approved longitudinal safety edge system to create a sloped edge profile onto the roadway shoulder. Use an approved safety edge system that compacts the HMA and provides a finished sloped wedge in accordance with the contract. Do not use a single plate strike off. Use a system that is adjustable to accommodate varying pavement thicknesses.

   Prior to commencing any shoulder work, provide a test section to demonstrate the safety edge finished shape and compaction of the proposed safety edge system. The Engineer may waive the test section if satisfactory evidence is provided that the proposed system has been successfully used on other MDOT or MDOT local agency projects. Ensure that all safety edge systems have been approved by the Engineer.

G. **Rolling.** Compact each layer of HMA in accordance with the contract and free of roller marks.

Keep the surface of the steel roller wheels moist during rolling.

Use a pneumatic tire roller on HMA overlay projects in the intermediate rolling position to knead HMA over existing pavement.

H. **Smoothness Requirements.** After final rolling, the Engineer may test the surface longitudinally and transversely using a 10-foot straightedge at selected locations in accordance with Michigan Test Method (MTM) 722. Construct the surface and correct variations, at no additional cost to the Department, to the tolerances specified in this subsection.

1. Base Course. Construct lower layers of base courses to a tolerance of ¾ inch and final layers of base courses to a tolerance of ⅜ inch.

2. Leveling and Top Course. For multiple course construction, construct lower courses to a tolerance of ¼ inch and top courses to a tolerance of ⅛ inch.

3. Single Course Overlays. Construct single courses to a tolerance of ¼ inch.

4. Longitudinal Joints. Construct adjacent lanes to a tolerance of ¼ inch for base and leveling courses and a tolerance of ⅛ inch for top courses.

5. Drainage Structures, Monument Boxes, and Water Shutoffs. Construct to a tolerance of ¼ inch.

I. Weather Limitations

1. **HMA Weather Limitations.** Place HMA in accordance with the following restrictions:

    a. Do not place HMA or apply bond coat when moisture on the existing surface prevents curing;

    b. Do not place HMA unless the temperature of the surface being paved is at least 35°F and there is no frost on or in the grade or on the surface being paved, unless otherwise approved by the Engineer in writing;

    c. Place only HMA courses that are greater than 200 pounds per square yard if the temperature of the surface being paved is greater than 35°F;

    d. Place only HMA courses that are greater than 120 pounds per square yard if the temperature of the surface being paved is at least 40°F; and

    e. Place any HMA course if the temperature of the surface being paved is at least 50°F.

J. **Protection of Structures.** Protect bridges, curbs, gutters, driveways, sidewalks, barriers, and other appurtenances to prevent surfaces from becoming discolored during application of bond coat or HMA to the road surface. Remove material from appurtenances, as directed by the Engineer, at no additional cost to the Department.

K. **Aggregate Shoulders.** On resurfacing projects, scarify existing aggregate shoulder surfaces before placing new aggregate material.

Maintain the shoulder for vehicles to pass the construction equipment. If Contractor operations or traffic disturbs the area between the pavement and the right-of-way line, restore the area to a condition approved by the Engineer at no additional cost to the Department.

L. **Monument Boxes.** Place or adjust monument boxes in accordance with section 821.

M. **Quality Control Plan.** Prepare and implement a QC plan for HMA in accordance with MDOT's HMA Production Manual.

Make adjustments in process controls to prevent production of non- conforming material instead of accepting payment at a reduced price. The Department will not allow continual production of non-conforming material at a reduced price instead of making adjustments.

The Engineer will not perform sampling or testing for QC or assist in controlling the HMA production and placement operations.

N. **HMA Mix Acceptance.** The Engineer will inspect field-placed material, perform QA sampling and testing, and monitor Contractor adherence to the Contractor's HMA QC Plan.

1. **HMA Field-Placed Inspection.** The Engineer will perform a visual inspection of HMA to identify areas requiring corrective action. The Engineer will inspect the base and leveling courses within 18 hours and the top course within 36 hours of placement. If the Engineer determines that corrective action is required, do not pave overlying courses until after corrective action is completed and the Engineer determines that the pavement is in conformance with the contract.

   The Engineer will determine the need for corrective action based on the factors specified in Table 501-5. Corrective action may include remedial treatment, including crack or surface sealing, or replacement.

   Submit an action plan to the Engineer that addresses all factors that resulted in the need for corrective action. Complete all corrective action required to repair or replace unacceptable work at no additional cost to the Department.

   If the Engineer and the Contractor agree, the Department may make a contract adjustment of no greater than 100% of the bid price for corrective action.

Table 501-5:
HMA Criteria for Corrective Action

Criterion[a]	Length	Extent[b]	Severity	Corrective Action[c]
Segregation	—	>215 ft²/ 328-foot LL	Heavy[d]	Replace
Rutting	—	>32 feet	>¼ inch average depth over the length of occurrence	Replace
Flushing	—	>108 ft²/ 328-foot LL	High[e]	Replace
Edge of paved shoulder	>33 feet	Visible ledges	>3 inches	Trim
Crack[g]	Any	Any	All	Seal[f]

LL = lane length

(a) Criteria apply to all courses except flushing, which applies to the top course only.

(b) Extent is calculated by summing locations within the required length.

(c) The appropriate corrective action depends on the extent and severity of the criteria and on the intended service life of the pavement.

(d) Segregation severity will be determined in accordance with MTM 326. If segregation thresholds are met twice on a paving course, the use of an MTD for the remaining paving for that course may be required at no additional cost to the Department.

(e) Flushing severe enough to significantly affect surface friction (Friction Number <35).

(f) Other corrective action may be required as crack frequency increases.

(g) A reflective crack determined by the Engineer to be caused by an underlying condition does not require corrective action.

The Department will not grant extensions of time for repair work to meet the inspection acceptance requirements specified in subsection 501.03.N.1.

The Engineer will determine the area subject to corrective action, for removal and replacement of top courses, as the longitudinal extent of corrective action multiplied by the width of the paving course affected.

The Department will accept HMA subject to corrective action as follows:

a. HMA placed for corrective action involving full removal and replacement will be accepted in accordance with the contract.

b. The area requiring corrective action other than full removal and replacement will not be measured for incentive payment.

c. If more than 10% of the area of a sublot requires corrective action, the sublot will not be measured for incentive payment.

2. **HMA Testing Acceptance.** The Engineer will accept HMA based on visual inspection, small tonnage, or QA sampling and testing acceptance criteria The Engineer will notify the Contractor before conducting QA sampling to allow the Contractor to witness the sampling, but not in a manner that will allow alteration of production in anticipation of sampling. The Engineer will conduct QA sampling in accordance with MTM 313 or MTM 324.

a. **Visual Inspection Acceptance Criteria.** The Engineer may accept quantities less than 500 tons, of any individual mixture, in accordance with MDOT's Materials Quality Assurance Procedures (MQAP) Manual.

b. **Temporary Pavement Acceptance Criteria.** The basis for measuring the mixture quality is QC testing and the QC processes specified in the applicable contract specifications for Superpave or Marshall mixes. Provide a copy of QC result to the Department within 24 hours upon request. The Department is not required to perform QA testing for the temporary HMA but reserves the right to perform verification testing. All materials and HMA mixture requirements apply. The initial production lots will be waived upon request. There are no pay factor or price adjustments based on mixture volumetrics for the temporary HMA.

Perform all maintenance with the exception of snow and ice removal during the seasonal shutdown period. Maintain temporary pavement until the completion of the contract or the opening to traffic of the new pavement.

Correct all deficiencies with the temporary pavement. The Engineer will make a negative adjustment for deficiencies requiring repairs or renewals, not corrected within the time frames stated in section 812 and for each occurrence that maintenance is required on the temporary HMA. Contract price adjustments will be made, according to Table 501-6, for each occurrence that repairs or renewals are required on the temporary roadway that are not attributable to normal wear and tear of traffic, weather, or an inadequate base condition not addressed in the contract.

O. **Asphalt Binder Acceptance.** The Department will accept asphalt binder in accordance with Department procedures.

Table 501-6:

Contract Adjustments for Maintenance of Temporary Pavement

ADT[a]	Per Maintenance Occurrence
0–10,000	$2,000[b]
10,000–40,000	$4,000[b]
≥40,000	$8,000[b]

(a) Based on average daily traffic (ADT) shown on Title Sheet

(b) The contract adjustment will be doubled if the Contractor 's *HMA-QC Plan* is not adhered to.

501.04 MEASUREMENT AND PAYMENT

A. **HMA, (type), High Stress.** Not Used.

B. **Pavement for Butt Joints, Removal.** Not Used.

C. **Edge Trimming.** If required, Edge Trimming shall be incidental to the project.

D. **Cold Milling HMA Surface.** Not Used.

E. **Pavement, Cleaning.** Pavement Cleaning shall be incidental to the project.

F. **Joint and Crack, Cleanout.** Not Used.

G. **Hand Patching.** Not Used.

H. **Removing HMA Surface.** The Engineer will measure, and the Department will pay for removing HMA surface, no greater than 12 inches thick, overlying a material designated for removal or that is required to remain in place, as HMA Surface, Rem. The unit price for HMA Surface, Rem includes the cost of edge cutting to establish a neat line, as required, and removal and disposal of the HMA material.

For removal of HMA surfaces from structures, the unit price for HMA Surface, Rem includes the cost of removing old membrane.

The Engineer will measure, and the Department will pay for removing HMA surface, greater than 12 inches thick, overlying a material designated for removal or that is required to remain in place, as Pavt, Rem in accordance with subsection 204.04.

I. **Pavement Joint and Crack Repair.** Not Used.

J. **Safety Edge.** Not Used.

K. **HMA**. THE ENGINEER WILL MEASURE, AND THE DEPARTMENT WILL PAY FOR, HMA AND HMA, TEMP PAVT (MIX TYPE) OF THE MIX SPECIFIED BASED ON THE WEIGHT PLACED, AS SUPPORTED BY WEIGH TICKETS. THE ENGINEER WILL ADJUST THE UNIT PRICE FOR HMA OF THE MIX SPECIFIED, IN ACCORDANCE WITH THE CONTRACT.

501.05 **BASIS OF PAYMENT**

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-501.05.01	HMA, 5 EML	Ton (TN)
MDOT-501.05.02	HMA 5 EML – Bid Alt 1	Ton (TN)

END OF ITEM MDOT-501

Item MDOT-204 Removing Miscellaneous Structures and Materials

603.01 DESCRIPTION

This work consists of restoring concrete pavement including the following:

A. Removing and repairing portions of a concrete pavement, one lane wide and 100 feet long, or less, with reinforced and non-reinforced portland cement concrete, with the type of joint required;

B. Diamond grinding and grooving portland cement concrete pavement;

C. Resawing and sealing existing pavement joints;

D. Sawing, cleaning, and sealing cracks in concrete pavements;

E. Removing sections of concrete pavement, one lane wide and greater than 100 feet long in accordance with section 204 or subsection 603.03.B.1, as determined by the Engineer; and

F. Replacing sections of concrete pavement one lane wide and greater than 100 feet long in accordance with section 602.

Refer to *MDOT Standard Plan R-44* series, *R-45* series, and the contract for details.

603.02. MATERIALS

Provide material in accordance with the following sections:

Base Course Aggregate, 4G, 21AA, 22A 902

Curing Materials for Pavements..... 903

Insulating Blankets..... 903

HMA Mixtures for Restoring Shoulders..... 904

Steel Reinforcement 905

Joint Spall Repair Materials..... 914

Bond Breaker Material 914

Epoxy Coated Dowel Bars and Deformed Tie Bars 914

Joint Materials……914

Concrete, Grades, 3500, 3500HP 1004

Concrete, Grade P-NC..... 1006

Provide the concrete grade necessary to obtain the strength specified in Table 603-1 in the anticipated curing time, as determined by the Engineer. The Engineer will not require 28-day compressive strength test cylinders for concrete pavement repairs. The Engineer will perform flexural strength testing of the field cured test specimens. Acceptance will be based on the specimens attaining the minimum flexural strength prior to opening the concrete pavement repair to vehicular traffic.

Table 603-1: Opening to Traffic Strengths

Anticipated Curing Time	Concrete Grade	Minimum Flexural Strength
<72 hours	Grade P-NC[(a)]	300 psi
≥3 days	Grade 3500, 3500HP	550 psi

(a) The Engineer may approve the use of a non-chloride Type A water reducer, a non-chloride Type C accelerating, or a Type E water-reducing and accelerating admixture from the Qualified Products List to achieve the flexural strength requirements.

603.03 CONSTRUCTION

A. **Equipment Requirements.** Use equipment necessary to perform the work in accordance with section 602 and the following:

1. **Drilling Machine.** Use a drilling machine and use methods to drill holes in the existing pavement vertical surfaces in accordance with the following:

   a. Support the drill on rails that rest on the pavement surface at both ends of an 8-foot-long repair, or by other alignment methods approved by the Engineer, to ensure holes meet the requirements of MDOT Standard Plan R-44 series;

   b. Provide a drill that uses mechanically applied pressure for forward and reverse travel. Match the drill and pressure mechanism to drill the nominal depth holes to prevent cracking the concrete and spalling more than ½ inch horizontally or vertically; and

   c. Equip the drill with a snug-fitting drill guide bushing, positioned against the face of the concrete to prevent eccentricity or overriding of the holes more than 1⁄16 inch and to maintain the alignment tolerances.

2. **Grout Dispenser**

   a. **Bulk Grout Systems.** Use a grout dispenser and static mixing nozzle system recommended by the grout material manufacturer. Use a machine that proportions the components, mixes the components as they are extruded through the static nozzle, and deposits the mixed material in the back of the hole.

   Use two bulk grout dispensers on the project or use one bulk grout dispenser and a 2-day supply of prepackaged grout material, dispensers, and static mixing nozzles.

   b. **Prepackaged Injection Grout Systems**. Use a grout dispenser and static mixing nozzle supplied by the manufacturer of the grout material. Use a static mixing nozzle capable of depositing grout to the back of the hole.

3. **Vibratory or Roller Screeds.** Use a steel-shod vibratory screed, with the weight and vibrating frequency required to screed concrete flush with the existing pavement in a single pass.

   Use a roller screed with the weight and speed required to screed the concrete surface flush with the existing pavement in two or more passes.

   Use screeds at least 6 inches longer than the width of the concrete pavement repair.

4. **Diamond Grinding Equipment.** Use diamond blades, spaced as required for the application, and mounted on a self-propelled machine designed for grinding and texturing pavement. Use equipment that will not cause damage to the underlying surface of the pavement. Do not use grinding equipment that ravels or spalls the concrete pavement, fractures aggregate, or damages the transverse or longitudinal joints. Use grinding equipment that produces the required texture. To remove residue and excess water, use vacuum equipment that extracts the slurry material from the pavement and prevents dust from escaping into the air.

5. **Diamond Grooving Equipment.** Use diamond blades, spaced as required for the application, and mounted on a self-propelled machine with a minimum head width of 3 feet, designed for grooving pavement. Use equipment that will not cause damage to the underlying surface of the pavement. Do not use grooving equipment that ravels or spalls the concrete pavement, fractures aggregate, or damages the transverse or longitudinal joints. Grooving equipment must have sufficient power, traction, and stability and be able to achieve the specified uniform depth of cut, flush to all inlets, manholes, bridge joints, and other appurtenances within the paved area. To remove residue and excess water, use vacuum equipment that extracts the slurry material from the pavement and prevents dust from escaping into the air.

6. **Equipment for Sawing and Sealing Cracks.** Use equipment for sawing and sealing cracks in accordance with subsection 602.03.A.13. Equip the saw with a diamond blade with a diameter of 8 inches or less. Do not use routers.

B. **Construction of Concrete Pavement Repair.** Construct concrete pavement repairs, 100 feet long, or less, in accordance with section 602, except as modified by this subsection.

Remove existing concrete pavement in sections at least 4 feet long. When the repair area is within 4 feet of an existing joint extend the repair to at least 1 foot beyond the joint. When the repair area is within 8 feet of an adjacent repair, remove the concrete pavement between the two areas, or as directed by the Engineer.

Control the grades by using the adjacent pavements. If the lane adjacent to a repair area is damaged, cast the repair area and open to traffic, then perform the removal and recasting of concrete repairs in the adjacent lane. The Engineer must approve the adjacent lane repair.

If the grade cannot be established by using adjacent pavements, provide grade control according to subsections 602.03 and 824.03.

1. **Removing Existing Pavement (Concrete Pavement Repair)**

   a. **Removing and Repairing Pavement Damaged by the Contractor.** Do not use removal equipment that damages the concrete pavement that will remain in place.

      Repair spalls caused by the Contractor's operations in accordance with section 602 at no additional cost to the Department.

   b. **Planned Pavement Removal and Repair**. Remove part-depth or full-depth HMA patches, included in the portion of pavement being removed, as removal of concrete, without regard to additional effort that may be involved in the removal of dissimilar materials. Avoid disturbing the base during removal.

      Perform shoulder removal using the same method as concrete pavement removal.

If the repair areas include repairing concrete curb, curb and gutter, or valley gutter, remove and replace the curbing adjacent to the repair and in line with the joints of the repair. If curbing removal leaves a section length, less than 6 feet from the saw cut to the nearest existing curb expansion joint, remove and replace the curb to the existing curb expansion joint.

Do not begin sawing more than 2 weeks before concrete pavement removal. Make straight, transverse saw cuts, at right angles to the centerline of the concrete pavement, within 1 inch per lane width. Saw the longitudinal joint full-depth between adjacent lanes, ramps, shoulders, or curb and gutter. Use water, immediately after sawing, to flush slurry off the surface of the pavement.

Place concrete repairs the same day as the removal of existing concrete pavement. Remove concrete pavement between narrowly spaced saw cuts at the end of a slab with air hammers and hand tools. Except for utility cuts, install lifting devices in the slab. Lift the slab without disturbing the base. Clean the area with hand tools and remove slurry from sawed surfaces.

2. **Installing Dowels or Deformed Tie Bars in Transverse Joints.** Drill the vertical faces of the existing concrete pavement to allow the insertion of dowel bars or deformed tie bars. Re-drill holes that do not meet the required depth, diameter, and alignment, as directed by the Engineer, at no additional cost to the Department.

   Clean drilled holes using oil-free compressed air with a minimum pressure of 90 psi. Fully insert the air wand into the holes.

   Fill the clean drilled holes with an adhesive grout selected from the Qualified Products List. Fill the holes with adhesive grout to their full length to ensure the adhesive grout covers the embedded length of the inserted dowel bars or deformed bars. Slowly insert the bars into the holes using hand pressure and a twisting motion, until fully seated. Wipe away excess adhesive grout extruded around the bars. Do not proceed until the Engineer verifies the dowel bars are properly installed and the adhesive grout set.

   Drill or punch holes in the joint filler used for expansion joints (Erg) to match the location of the holes in the existing pavement. Drill or punch the holes in the joint filler to produce neat, clean holes without excessively tearing the filler. After anchoring the dowel bars in place, install the joint filler and position it against the existing pavement.

   Extend the joint filler the full-depth of the repair and install flush with the existing pavement surface. Place the joint filler in one continuous length, so it covers the entire vertical surface and is in full contact with the sawed joint face, unless otherwise approved by the Engineer.

   Coat the portions of dowel bars that extend beyond the face of the existing pavement or the joint filler with an approved bond-breaking coating. Do not coat deformed bars used with tied joints (Trg) or anchored-in-place lane ties with bond-breaking coating.

   Install an approved expansion cap on the end of each dowel bar for expansion joints (Erg), after applying the bond breaker.

3. **Site Preparation.** If the plans show base corrections, excavate and backfill in accordance with section 205 and section 302. When the existing base is more than 2 inches lower than the required grade, correct the low base by adding base course aggregate and compacting to the

required density and elevation. Increase the repair thickness, when the existing base is 2 inches or less below the required grade due to existing conditions or as a result of concrete pavement removal operations.

Set forms to the line and grade shown on the plans. Use one-piece forms for repairs 10 feet or less. For repairs greater than 10 feet, use forms that lock together or splice sections to provide a continuous form. Provide metal or wood forms. If using wood side forms, use lumber with a nominal thickness of at least 2 inches.

For reinforced concrete, position and support reinforcement in accordance with the MDOT Standard Plans.

4. **Longitudinal Joints.** If casting more than one lane in a single pour, construct longitudinal joints in line with the existing longitudinal joints. Construct longitudinal joints to a depth of one-third the thickness of the pavement by sawing or forming before opening to traffic.

   Install lane ties in accordance with MDOT Standard Plan R-44 series. Construct anchored-in-place lane ties in accordance with subsection 603.03.B.2, for deformed bars used with tied joints (Trg), except the use of handheld drills will be allowed.

5. **Transverse Joints.** If the contract requires an existing curb to be left in place, and there is an expansion space in the adjacent lane repair, saw an expansion joint (Esc) in the curb. Construct the joint in line with and equal in width to the expansion joint in the adjacent lane repair. Shape the joint filler to match the curb cross section.

6. **Placing Concrete.** Immediately before concrete placement, wet the faces of the existing pavement and the surface of the aggregate base with water.

   Cast each repair in one continuous full-depth operation. Consolidate the concrete using a hand-held immersion-type vibrator, approved by the Engineer. Consolidate the concrete around dowel bars, deformed tie bars, and deformed lane tie bars.

7. **Finishing Concrete.** Strike off the surface flush with the existing pavement surface at least twice with a vibratory or roller screed. Do not float instead of striking off. For repairs 15 feet long or less, place the screed parallel to the centerline of the roadway. For repairs greater than 15 feet long, place the screed perpendicular to the centerline.

   While the concrete is still plastic, check that the edges of the repair surface are flush with the edges of the existing concrete pavement, and verify the necessary grades are met.

   For repairs 10 feet long or less, place the straightedge parallel to the pavement centerline with the ends resting on the existing pavement and draw the straightedge across the repair. Use a straightedge no greater than 6 inches longer than the repair. Keep the straightedge in contact with the existing pavement while drawing it across the repair. Correct high or low spots greater than ⅛ inch, recheck the surface after making corrections, and eliminate irregularities.

   For repairs greater than 10 feet long, use a straightedge in accordance with subsection 602.03.I. Make the first and the last measurement with half the straightedge resting on the existing pavement. Make the second and the next to last measurement with 2 inches to 3 inches of the straightedge resting on the existing pavement. Correct high or low spots greater than ⅛ inch.

Before texturing, run an edger with a ⅛-inch to ¼-inch radius along the perimeter of the repair. Remove forms after the concrete attains the strength required to prevent sagging or spalling upon removal of the forms.

8. **Texturing.** Texture the surface of the repair to match texturing on the adjacent concrete pavement.

9. **Stenciling.** Stencil the month and the year in each repair in accordance with subsection 602.03.L. If repair operations cause the removal of the existing stationing, stencil the station in the repair at the required location.

10. **Curing.** Apply the curing compound immediately after free water evaporates from the concrete pavement surface. Do not delay curing compound application for other work during concrete pavement placing and finishing operations.

    Use white membrane curing compound, unless the repair requires a bituminous overlay. For repairs requiring bituminous overlay, use transparent curing compound. Apply the required curing compound in two coats, at a rate of at least 1 gallon per 25 square yards for each coat.

    Stop concrete pavement placement if the curing compound application process fails to meet the requirements specified in this subsection.

    Maintain the placed and finished concrete in a continuously moist condition, using fog mist, until membrane curing compound is applied.

    Alternative methods for keeping concrete continuously moist may be approved by the Engineer.

    Reapply curing compound immediately to surfaces damaged by rain, joint sawing, Contractor foot traffic, or other activities.

    Place insulated blankets to meet open-to-traffic requirements and protect the concrete pavement from weather damage. Provide insulated blankets at least 2 inches thick. When the air temperature falls below 50°F during the curing period, place blankets over the repaired area as soon as the curing compound dries. Secure edges and seams in the blanket to prevent heat loss. Protect the concrete until it attains the minimum flexural strength specified in Table 603-1.

    Comply with the methods included in the QC plan for achieving open-to-traffic strength within the required time period.

    The maturity method may be used at no additional cost to the Department, after submitting a plan to the Engineer for approval, to determine the in-place opening-to-traffic flexural strength. Make the necessary preliminary flexural strength versus opening-to-traffic time correlations before placing the concrete.

    Cure test beams for open-to-traffic strengths in the same manner as the repair.

11. **Cleaning Joints.** Remove concrete from the top of any joint filler prior to blast cleaning. Immediately before sealing joints, blast clean, except tied joints (Trg), and then finish cleaning the joint again using oil-free compressed air with a minimum pressure of 90 psi to remove all debris. Insert a backer rod in the bottom of the contraction joint (Crg) reservoir after the final cleaning and before sealing.

12. **Sawing Joints**. Do not construct reservoirs for seals in the following joints:

    a. Joints in base course repairs;

    b. Joints in repairs constructed in preparation for HMA overlays; and

    c. Reinforced anchored tied joints (Trg).

    For all other joints and saw cuts in concrete pavements, shoulders, or gutters caused by overcutting, clean and seal using hot-poured joint sealant.

    Before sealing joints, remove the joint filler from the top of the joint by sawing 1 inch wide and ½ inches deep.

    Saw joint reservoirs for the contraction joints (Crg).

    Saw joint reservoirs for C2 joints and E2 joints after the concrete pavement attains the strength required to prevent excess raveling or spalling, but before random cracks develop. Forming of joint reservoirs is not allowed. Saw the initial relief cut and extend the reservoir to the plan width and depth in accordance with subsection 602.03.N, or initially saw to the width and depth shown on the plans.

13. **Sealing or Resealing Transverse and Longitudinal Pavement Joints.** After completion of concrete pavement repairs, spall repairs, and pavement texturing, saw the transverse and longitudinal joints over the existing joint reservoir to remove existing sealant and produce a finished joint with two freshly sawed faces. Immediately after sawing, flush the joint reservoir with water to remove the slurry and debris. After final cleaning of the joints, insert a backer rod into the transverse joint, creating a 1:1 width-to-depth ratio for hot-poured sealant. Seal the joint reservoir to no greater than ⅛ inch (after cooling) below the concrete pavement surface for transverse and longitudinal joints and in accordance with subsection 602.03.S.

14. **HMA Shoulder Replacement.** Before opening to traffic, restore HMA shoulders to the existing line and grade using a plant-mixed HMA, as directed by the Engineer. Replace cold patch mixtures for temporary patching with plant-mixed HMA, unless the plans show shoulder reconstruction as part of the project. Compact the HMA using mechanical or hand methods required for the size of the repair area. Fill the voids and compact flush with the surrounding shoulder. Place HMA at the required compaction temperatures.

    Properly dispose of materials removed from the shoulder.

15. **Opening to Traffic.** The concrete pavement must attain the required minimum flexural strength, and all joints must be sawed and sealed in accordance with subsection 603.03.B before opening to traffic. The Engineer may allow traffic over the repair before the joints are cleaned and sealed.

C. **Diamond Grinding and Grooving Concrete Pavement.** Complete all pavement repair and joint restoration work, except sealing, before diamond grinding and grooving.

Diamond grind and groove concrete pavement in the longitudinal direction beginning and ending at lines perpendicular to the pavement centerline. Stop grinding and grooving if conditions cause water to freeze.

Do not disturb reflective pavement markers (RPMs). Taper grinding to the existing pavement surface within 2 inches of the RPM.

Texture at least 95% of the pavement surface unless otherwise directed by the Engineer. Extra depth grinding to eliminate minor depressions is not required.

After initial grinding, regrind faulted areas, greater than 1⁄16 inch, at transverse cracks and joints, until faulting is less than 1⁄16 inch.

Uniformly groove a parallel corduroy-type texture, consisting of grooves with a width of ⅛ inch and a depth of 5⁄32 inch with a tolerance of 1⁄32 inch. The grooves must be spaced at ¾ inch on center with a tolerance of 1⁄16 inch. Do not texture the pavement surface within 1½ inches of longitudinal joints. Provide a mean texture depth from 0.04 inch to 0.10 inch, in accordance with ASTM E965.

Construct a uniform transverse slope with no depressions or misalignment greater than ⅛ inch when checked with a 10-foot straightedge. The Engineer will not apply straightedge requirements across longitudinal joints or outside ground areas. Transition grind the shoulder to provide cross slope drainage.

To provide drainage and the required riding surface, transition grind auxiliary or ramp lanes from the mainline edge. The Engineer will determine the transitions from ground to unground pavement surfaces.

Seal joints after grinding and grooving.

1. **Control and Disposal of Grinding and Grooving Slurry.** Before beginning grinding and grooving, obtain the Engineer's approval of the slurry spreading and disposal method.

   Do not allow grinding and grooving slurry to enter enclosed drainage systems.

   If approved by the Engineer, spread slurry along the roadway slopes with the following restrictions:

   a. Spread slurry at least 5 feet away from the curb.

   b. Do not spread the slurry within 100 feet of a natural stream or lake.

   c. Do not spread slurry within 5 feet of a water-filled ditch.

   If surface runoff occurs, collect and haul the grinding and grooving slurry to an Engineer-approved location on the project at no additional cost to the Department.

2. **Testing Diamond Grinding and Grooving Slurry.** The Department will take random samples of the grinding and grooving slurry and cooling water for chemical testing. Allow Department personnel access to obtain the samples.

D. **Resealing Pavement Joints.** Saw, or re-saw, clean, and seal longitudinal and transverse concrete pavement joints in accordance with subsection 602.03.S and the following.

Saw longitudinal and transverse joints as required by the contract. Re-saw existing longitudinal and transverse joints from 1 inch to 1¼ inches deep, and of sufficient width to establish a clean face

each side of the joint reservoir. Immediately after sawing, flush the joint reservoir with water to remove slurry and debris.

Provide a final cleaning just before sealing, in accordance with subsection 602.03.R. After the final cleaning, insert a backer rod into the transverse joint to provide a 1:1 width-to-depth ratio of joint sealant.

The joint faces and pavement surface must be dry before sealing joints. Seal the joint reservoir to no more than ⅛ inch (after cooling) below the surface of the pavement.

E. **Sawing and Sealing Cracks.** Seal cracks with a hot-poured sealant as follows:

Saw cracks from ½ inch to ⅝ inch deep and from ⅜ inch to ½ inch wide.

After sawing, use hand tools or a lightweight chipping hammer to remove slivers of concrete, less than 1 inch wide, along the crack. Immediately before sealing, blast clean both faces of the sawed crack with dry abrasive to remove contamination and texture the faces. After dry abrasive blasting, clean the crack to remove debris using oil-free compressed air with a minimum pressure of 90 psi.

The joint faces and pavement surface must be dry before sealing joints. If the crack below the sealant reservoir is greater than ⅜ inch wide, insert a backer rod into the crack to form the bottom of the reservoir at the required depth. Seal the crack to no more than ⅛ inch (after cooling) below the surface of the pavement.

If required by the crown of the roadway and the slope of the shoulder, fill the reservoir in two or more passes, place temporary dikes in the sealed reservoir, or use both methods. Remove the temporary dikes before the sealant fully cools and seal the resulting cavity. Apply the additional sealant before the previous application becomes contaminated.

603.04. MEASUREMENT AND PAYMENT

A. **Price Adjustments for Concrete Pavement Repairs.** The Engineer will determine the final concrete pavement repair thickness in accordance with subsection 603.04.C. The Department may core the concrete pavement repairs and will adjust the unit prices for repairs that do not meet the required depth or the required reinforcement location in accordance with subsection 602.04.

B. **Pavement Repair, Removal.** The Department considers Pavt Repr, Rem the removal of pavement sections without disturbing the base, as shown on the plans. The unit price for Pavt Repr, Rem includes the cost of the following:

1. Moving from repair to repair;
2. Establishing grade;
3. Saw cutting;
4. Removing adjacent concrete shoulders, curb, curb and gutter, and valley gutter;

5. Removing part-depth or full-depth HMA patches;

6. Lifting the repair section without disturbing the base;

7. Loading, hauling, and disposing of the removed material; and

8. Placing HMA mixture, as necessary, to restore the shoulders to the existing line and grade.

The Department will include the pay item Saw Cut, Intermediate for sections of pavement on which the plans show Pavt Repr, Rem. The Department will not include the pay item Saw Cut, Intermediate for sections of pavement on which the plans show Pavt, Rem. The Department will pay for intermediate saw cuts for concrete pavement repairs over 6 feet long, but less than 100 feet long, to allow loading onto hauling units, as Saw Cut, Intermediate. The Department will not pay separately for additional saw cuts to reduce slabs into pieces smaller than one lane width by 6 feet long.

The Department will pay for the removal of portions of concrete that contain partial or full-depth HMA patches as Pavt Repr, Rem.

C. **Pavement Repair, Reinforced Concrete, and Pavement Repair, Non-reinforced Concrete.** The Department will establish a concrete pavement thickness for repairs, as shown on the plans, based on the original plan thickness of the existing concrete pavement plus 1 inch. The minimum thickness of the concrete pavement repair may vary by no more than 1 inch from the thickness shown on the plans.

The Department will not pay separately for work required to correct low-base conditions caused by Contractor removal operations. The Department will pay for site preparation to correct base, more than 2 inches below the required grade, not caused by Contractor operations, under the relevant pay items. If the contract does not include a relevant pay item, the Department will pay for base corrections greater than 2 inches deep, not caused by Contractor operations, as extra work.

1. Repair. The Engineer will measure Pavt Repr, Reinf Conc and Pavt Repr, Nonreinf Conc, of the thickness specified, longitudinally along the pavement surface, and will use the transverse dimension shown on the plans.

   The unit prices for Pavt Repr, Reinf Conc and Pavt Repr, Nonreinf Conc include the cost of the following:

   a. Moving from repair to repair;

   b. Establishing grade;

   c. Providing, placing, finishing, texturing, stenciling, and curing the concrete;

   d. Providing and placing bar chairs and the steel reinforcement; and

   e. Providing additional concrete, as necessary, to correct low-base conditions that do not exceed 2 inches measured from the required grade.

D. **Repair of Concrete Shoulders, Curbs, and Curb and Gutter.** Not Used.

E. Joints

1. **Contraction Joints (Crg).** Joint, Contraction, Crg shall be incidental to the Pvmt Repr and includes the following:
    a. Making the saw cuts required at the ends of the repairs;
    b. Removing saw slurry from the pavement surface and sawed faces;
    c. Drilling and cleaning holes for dowel bars and deformed bars;
    d. Providing, mixing, and installing adhesive grout;
    e. Providing and installing dowel bars or deformed bars;
    f. Providing and applying the dowel bar bond breaker coating;
    g. Sawing the joint reservoirs;
    h. Cleaning and preparing the joint reservoir; and
    i. Providing and installing the joint reservoir sealant.
2. **Expansion Joint, Esc.** Joint Expansion, Esc shall be incidental to the Pvmt Repr and includes the cost of sawing the joint, providing and installing the joint filler material, and installing the joint reservoir sealant.
3. **Expansion, Erg.** Joint Expansion, Erg shall be incidental to the Pvmt Repr and includes the cost of the following:
    a. Making the saw cuts required at the ends of the repairs;
    b. Removing the saw slurry from the pavement surface and sawed faces;
    c. Drilling and cleaning the holes for the dowel bars;
    d. Providing, mixing, and installing the adhesive grout;
    e. Providing and installing the dowel bars;
    f. Providing and applying the dowel bar bond breaker coating;
    g. Providing, drilling or punching, and installing the joint filler;
    h. Providing and installing the dowel bar expansion caps;
    i. Sawing the joint reservoirs;
    j. Cleaning and preparing the joint reservoir; and
    k. Providing and installing the joint reservoir sealant.

The Department will pay for sawing depths greater than 1 inch below the depth shown on the plans as extra work.

4. **Transverse Plane-of-Weakness Joints.** Not Used.
5. **Tied Joints (Trg).** Joint, Tied, Trg shall be incidental to the Pvmt Repr and includes the cost of the following:

a. Removing saw slurry from the pavement surface and sawed faces;

b. Drilling and cleaning holes for dowel bars and deformed bars;

c. Providing, mixing, and installing adhesive grout; and

d. Providing and installing dowel bars or deformed bars.

6. Longitudinal Joints. The unit prices for other pay items include the cost of sawing and sealing.

F. **Lane Tie, Epoxy Anchored.** Lane Tie, Epoxy Anchored shall be incidental to the Pvmt Repr and includes the cost of the following:

1. Drilling and cleaning the holes;

2. Providing, mixing, and installing the adhesive grout; and

3. Providing and installing the deformed bars.

The unit prices for other pay items include the cost of final trim and clean-up, part-width construction, and restoring shoulders.

G. **Diamond Grinding and Grooving Concrete Pavement.** Not Used.

H. **Resealing Transverse and Longitudinal Joints with Hot-Poured Rubber.** The Engineer will measure Resealing Trans Joints with Hot-Poured Rubber and Resealing Longit Joints with Hot-Poured Rubber in a straight line in the direction of each joint. Resealing Trans Joints with Hot-Poured Rubber and Resealing Longit Joints with Hot-Poured Rubber shall be incidental to the Pvmt Repr and include the cost of removing existing sealants, sawing, cleaning, and sealing the joints.

I. **Crack Sealing, Concrete Pavement**. Not Used.

603.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-603.05.01	Saw Cut, Intermediate	Linear Foot (LF)
MDOT-603.05.02	Pavt Repr, Nonreinf Conc, 10 inch - Bid Alt 1	Square Yard (SY)
MDOT-603.05.03	Saw Cut, Intermediate - Bid Alt 1	Linear Foot (LF)

END OF ITEM MDOT-603

Item MDOT-808 Fencing

808.01 DESCRIPTION

This work consists of providing and erecting, or moving existing, woven wire fence, temporary fence, protective fence, chain link fence, high-tensile wire fence, or pedestrian fencing of structures.

808.02 MATERIALS

Provide materials in accordance with the following sections:

Sound Earth……. 205

Fencing Materials 907

Structure Expansion Anchors and Bolts.....914

Concrete, Grade 3000 1004

A. **Protective Fencing.** Provide new or used material for temporary and protective fencing.

B. **Fence Fabric.** Provide either zinc-coated steel or aluminum-coated steel fabric for chain link fence. Only use polyvinyl chloride (PVC) coated fence fabric if required by the contract.

C. **Moving and Salvaging Fence.** The Engineer may approve material salvaged from moved, temporary, or protective fencing for use as permanent fence provided it meets the requirements of section 907. Provide additional materials in accordance with section 907.

D. **Polyvinyl Chloride.** Meet the requirements in subsection 907.04 with the exception that the chain link fence and gates must be 48-inch thermal fused with a black, plasticized PVC coating.

1. **Fabric.** The vinyl-coated steel chain link fence must meet the requirements of ASTM F668 Class 2b. The core must be 0.148 inch in diameter. The mesh size must be 2 inches. The PVC coating must be black in accordance with ASTM F934.

2. **Framing.** The framing must be hot-dipped galvanized prior to vinyl coating. The thickness of the vinyl coating must be 10 to 14 mils applied by fusion bonding.

Provide a general certification that the materials provided meet the requirements stated above. The Department will conduct acceptance testing in accordance with subsection 907.02.

808.03 CONSTRUCTION

Erect a taut fence to the line required by the contract. Dispose of surplus excavated material and other debris in accordance with subsection 205.03.P. The Engineer will designate and mark trees and other vegetation to be saved. Construct the fence near designated vegetation and in naturally occurring wet areas, by hand, as directed by the Engineer.

A. **Concrete.** Place concrete per section 1004.

B. **Woven Wire Fence.** Use wood posts in swamps and areas of unstable soil.

If necessary to confine livestock, erect the permanent fence before removing the existing fence. If the permanent fence must be installed in the same location as the existing fence, install temporary fencing to be paid for as Fence, Temp at the contract unit price.

Install fencing near schools, play areas, or residential yards prior to removing the existing fencing.

1. **Clearing Fence Line.** Where clearing for fence is required, clear the fence line in accordance with subsection 201.03.C.

2. **Setting Posts.** Dig holes for posts in accordance with the *MDOT Standard Plan R-101* series with a tolerance of 3 inches.

   Steel posts must be plumb. Remove and replace bent or damaged posts.

   When placing posts, maintain the tops of posts at a uniform height above the ground.

   Set an intersection post in line with intersecting fences and brace in line with the intersecting fence. Connect both intersecting fences to the intersection post.

3. **Anchoring and Bracing Wood Posts.** Not Used.

4. **Anchoring and Bracing Steel Posts**. Anchor and brace steel posts in accordance with the *MDOT Standard Plan R-101* series.

   Brace end and gate posts with one brace in the direction of strain. Brace corner, angle, and intermediate posts in both directions. Brace intersection posts in three directions. Fasten braces near the top of the post. At depressions and alignment angles where stresses are created that may pull the posts from the ground, set the line posts in concrete.

5. **Installing Fabric and Barbed Wire**. Wrap each horizontal strand of wire around the end, corner, gate, or intermediate braced post and wind around the wire leading up to the post.

   Stretch the wire fabric taut and fasten it to each post with the bottom of the fabric 2 inches above the ground. Use line posts as stretching anchorage only if they are anchored in concrete.

   Obtain the Engineer's approval for the method of splicing wires in woven wire fabric and barbed wire. Make the distance between the vertical wire stays, next to the splice, equal to the unspliced sections of woven wire fabric. Splice a woven wire and barbed wire fence only if connecting two rolls of wire. Do not make intermediate splices.

   Fasten the fence fabric to each steel post with at least six wire clamps.

   Fasten the barbed wire to each post 3 to 4 inches above the fabric.

6. **Installing Vinyl Coated Chain Link Fence**. Conduct the work according to section 808, the *MDOT Standard Plan R-98* series for the gates, and the *MDOT Special Detail 99* for the fence.

   Electronically submit one complete set of manufacturer's specifications to the Engineer for approval a minimum of 14 work days prior to fabrication of the materials. Do not fabricate any materials prior to receiving approval from the Engineer.

C. **Temporary Fence.** Erect temporary fence in accordance with subsection 808.03.A and subsection 808.03.B, except as modified by the following:

1. **Setting Posts.** Set line posts at least 2 feet into the ground and end posts at least 3 feet into the ground and do not trim the tops. The Engineer may allow the omission of intermediate braced posts.

2. **Installing Fabric.** Attach the fabric to steel posts with at least four wire clamps.

3. **Removing Temporary Fence.** Remove and dispose of the temporary fence, or salvage in accordance with subsection 808.02.C.

D. **Protective Fence.** Place a protective fence around excavations for bridges and pump stations, and other areas of the project in accordance with subsection 104.07.B and the plans, or as directed by the Engineer. Erect protective fence in accordance with subsection 808.03.A and subsection 808.03.B, except as modified by the following:

1. **Anchoring and Bracing Posts.** Anchor and brace enough posts to keep the fabric taut.

2. **Maintaining Fence.** Maintain the protective fence until the Engineer directs its removal or accepts the project.

3. **Removing Protective Fence.** Remove and dispose of the protective fence.

E. **Chain Link Fence.** Erect chain link fence on steel posts set in concrete.

1. **Clearing Fence Line.** Clear the fence line in accordance with subsection 201.03.C.

2. **Setting Posts.** Set posts in concrete and brace. Install angle posts where the alignment of the fence deflects more than 10 degrees.

   Set an intersection post in line with intersecting fences. Connect both intersecting fences to the intersection post.

   Fit posts with Department-approved post caps.

3. **Braces.** Fasten braces to the end, corner, angle, intersection, gate, and intermediate braced posts with required steel fasteners.

4. **Installing Fabric and Top Tension Wire.** Stretch chain link fence fabric taut and fasten to each post with Department-approved fasteners. Space the fasteners no greater than 12 inches apart on the posts. Fasten the fence fabric to the tension wire, at no greater than 15-inch intervals, using fasteners fabricated from 12-gauge galvanized wire. Close fasteners to the full crimp position around the tension wire and fence fabric.

F. **High-Tensile Wire Fence.** Construct high-tensile wire fence in accordance with subsections 808.03.A and 808.03.B. Erect the wires in accordance with the manufacturer's recommendations.

G. **Fencing on Structures.** Construct fencing on structures in accordance with subsection 808.03.E. Install a fully compressed lock washer on the bolt threads of exposed nuts. Construct handrails, as shown on the plans, as part of the fencing in accordance with section 707.

H. **Moving Fence.** Remove the existing fence without damaging the materials. Set posts and anchors in the same manner and to the same depth and spacing as the original fence. Place the

reset fence in at least as good condition as the existing fence before it was moved. If the fence consists of wire fabric, draw it taut but do not overstress the salvaged materials. Replace damaged or destroyed materials at no additional cost to the Department.

808.04 Measurement and Payment

A. **Concrete Acceptance.** Conduct concrete QC as specified in section 1002. The Engineer will conduct QA as specified in section 1003. The Department will pay for this work based on the QA results.

B. **Fence.** The Engineer will measure fence in place and will not include gate openings in the measurement for **Fence, Temp; Fence, Woven Wire; Fence, Moving**; and **Fence, Chain Link**. The Engineer will measure gates separately.

The unit price for fence of the type required includes the cost of providing and installing posts, braces, fabric, and hardware.

The Department will not make adjustments in price for handwork required to avoid damage to trees and vegetation designated to be saved.

If required, the Engineer will measure, and the Department will pay for, barbed wire separately except that the unit price for **Fence, Chain Link,__ inch, with (number) Strand of Barbed Wire** includes barbed wire.

C. **Temporary and Protective Fence.** The Department will not pay separately for protective fence required in accordance with subsection 104.07.B.

If the Engineer directs, or the plans show, the use of protective fence, the unit price for **Fence, Protective** includes the cost of providing and placing.

The unit prices for **Fence, Temp** and **Fence, Protective** include the cost of providing, erecting, maintaining, removing, and disposing of fence.

The Engineer will not deduct openings from measurements for **Fence, Protective**. The Engineer will not measure gates separately.

D. **Fence, Structure.** The unit price for **Fence, Structure** includes the cost of providing and installing posts, braces, and fabric, and all supporting, connecting, and auxiliary elements, including handrails if shown on the plans, for the erection of fences on existing or new structures.

E. **Fence, Moving.** The Engineer will measure **Fence, Moving** in place at its new location. The unit price for **Fence, Moving** includes the cost of disassembling, moving the fence, and installing it in its new location. The unit price also includes replacing posts or fabric damaged or destroyed by the Contractor’s removal operation.

The Department will pay for new posts or new fence material, if shown on the plans or required by the Engineer, at the contract unit price for these items. If the contract does not include new post or new fence material pay items, the Department will pay for these as extra work.

816.04 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-808.05.01	Fence, Chain Link, 96", with 3 Strands of Barbed Wire	Linear Foot (LF)
MDOT-808.05.02	Fence, Chain Link, 96", with 3 Strands of Barbed Wire - Bid Alt 1	Linear Foot (LF)

END OF ITEM MDOT-808

Item MDOT-811 Permanent Pavement Markings

811.01 DESCRIPTION

This work consists of providing and applying retroreflective permanent pavement markings in accordance with the MMUTCD. Provide markings, shapes, spacing, and dimensions that conform to MDOT's *Pavement Marking Standard Plans*.

811.02. MATERIALS

Provide materials in accordance with the following sections:

Glass Beads…… 920

Wet Reflective (WR) Optics 920

Waterborne Pavement Marking Material 920

Low Temperature Waterborne Pavement Marking Material 920

Regular Dry Pavement Marking Material 920

Cold Plastic Pavement Marking Material 920

Thermoplastic Pavement Marking Material 920

Sprayable Thermoplastic Pavement Marking Material 920

Polyurea Pavement Marking Material 920

Modified Epoxy Pavement Marking Material 920

Preformed Thermoplastic Pavement Marking Material 920

Provide the Material Safety Data Sheets to the Engineer for required materials and supplies. Dispose of unused material and containers in accordance with the federal Resource Conservation and Recovery Act (RCRA) of 1976 (42 USC 6901 et seq.) and Part 111, Hazardous Waste Management, of the Natural Resources and Environmental Protection Act (MCL 324.11101 et seq.).

Provide samples of permanent pavement marking materials on Department request.

Ship all material to the job site in sturdy containers marked in accordance with subsection 920.01.A.

Submit to the Engineer prior to the start of work the manufacturer's recommended application rate of the wet reflective (WR) optics and the liquid applied pavement marking binder to be used on the project. If the manufacturer's recommended application rate differs from the specified rate in Table 811-1, the manufacturer's recommended rate supersedes the table values.

Table 811-1:

Pavement Marking Material Application Rates per Mile[(a)(b)]

Binder Type	Wet Binder Thickness without Beads (mil)	Min. Dry Thickness with Beads (mil)	Binder Volume/ Weight and Bead Weight	Line Type							
				Broken				Solid			
				4 inch	6 inch	8 inch	12 inch	4 inch	6 inch	8 inch	12 inch
Waterborne	15	20	Binder (gal)	4.2	6.2	8.3	12.4	16.5	24.7	33	49.4
			Bead (lb)	34	50	67	100	132	198	264	396
Low temperature waterborne	15	20	Binder (gal)	4.2	6.2	8.3	12.4	16.5	24.7	33	49.4
			Bead (lb)	34	50	67	100	132	198	264	396
Regular dry	15	20	Binder (gal)	4	6	8	12	16	24	32	48
			Bead (lb)	24	36	48	72	96	144	192	288
Thermoplastic	90	110	Binder (lb)	435	653	870	1,305	1,740	2,610	3,480	5,220
			Bead (lb)	50	75	100	150	200	300	400	600
Sprayable thermoplastic	30	40	Binder (lb)	140	210	280	420	560	840	1,120	1,680
			Bead (lb)	50	75	100	150	200	300	400	600
Modified epoxy	20	45	Binder (gal)	5.5	8.25	11	17	22	33	44	66
			Bead (lb)	As dir	ected by t	he manuf	acturer	As dire	cted by th	e manufa	cturer
Polyurea	20	45	Binder (gal)	5.5	8.25	11	17	22	33	44	66
			Bead (lb)	As dir	ected by t	he manuf	acturer	As dire	cted by th	e manufa	cturer

(a) Binder yield indicates the amount (gal or lbs/mile) needed to produce the required mil thickness without drop on beads.

(b) Bead yield indicates the amount (lbs/mile) of drop on beads required for the given binder.

811.03. CONSTRUCTION

A. **Equipment.** Provide self-propelled equipment certified by the Department in accordance with MDOT's *Equipment Certification Guidelines – Pavement Markings*. Certification is effective for 2 years. The Engineer may approve other equipment for special markings or areas inaccessible to self-propelled pavement marking equipment.

Apply longitudinal lines using certified self-propelled pavement marking equipment. Operate marking equipment at no greater than the certified speed. The Engineer will assume that a striper operating above the certified working speed has operated at that speed for the entire day.

The Department may inspect the equipment at any time.

Use equipment capable of uniformly applying material to the required length and width.

Provide equipment for placing centerlines capable of applying three 4-inch-minimum-width lines on a two-lane road in one pass. If applying multiple centerlines, use three spray guns positioned 6 inches on center. For two-lane freeways, apply the lane line from the left lane. For freeways with at least three lanes, apply the right lane line with the right edgeline when the right lane line and edgeline are the same material.

Use an easily adjusted, dashing mechanism to retrace existing lane or centerline markings.

Use a self-propelled pavement marker capable of marking pavement in either direction on a roadway. Use a continuous skip cycle. Do not zero or return the cycle control unit to the beginning or start of a new cycle.

Provide a distance meter to measure the length of each line.

The Engineer may check the calibration of metering devices at any time. If the Engineer determines that the equipment is unsatisfactory, use other methods approved by the Engineer.

Use equipment for placing hot-applied thermoplastic and sprayable thermoplastic material that can maintain the temperature recommended by the material manufacturer.

Allow time for the Engineer to inspect traffic control devices as shown in MDOT's *Pavement Marking Convoy Typicals* prior to marking applications. Correct traffic control devices not approved by the Engineer before continuing. If applying markings on a roadway closed to traffic, the traffic control devices specified in MDOT's *Pavement Marking Convoy Typicals* are not required, unless otherwise directed by the Engineer.

B. **General.** The Department will not provide storage buildings or space for permanent pavement marking equipment or materials.

If pavement marking plan sheets and/or Witness, Log are included in the project, the markings must be laid out by the Contractor prior to the permanent markings being applied. Layout is considered incidental to placement of permanent pavement markings. Provide the Engineer documented notice at least 2 calendar days prior to the Contractor's pavement marking crew arriving onsite to layout or layout and stripe. The onsite Engineer must approve the layout prior to the marking application. Notify the Engineer if it is discovered during layout that the

pavement width or geometry has been altered or is different from the planned or logged configuration. The Contractor and Engineer will discuss and document the resolution for marking layout in such areas. If pavement marking plans and/or Witness, Log are not in the project, it is the responsibility of the Engineer to provide layout for the permanent pavement markings.

For any portion of the project that pavement marking plan sheets or details are included, layout the permanent pavement markings according to the pavement marking plans. If the contract calls for Witness, Log, the Contractor must witness and log the existing markings in accordance with the following.

Provide a pavement marking layout plan consisting of aerial imagery, computer-generated drawings and/or hand sketches with legibly handwritten or documented dimensions. When using aerial imagery, the pavement markings must be sketched in for any sections where they are not clearly visible. Required dimensions include turn lane storage lengths, taper lengths, stop bar location as measured from the centerline of the intersection or the crosswalk markings (if present), symbol and legend locations, cross hatching location and spacing, longitudinal line style changes, and any other dimensions required to return markings to the

pre-construction configuration. The layout plan must additionally indicate lane widths of all lanes, shoulders, bike lanes, and other features at all transition points where these elements are added and/or removed and at every ½-mile interval where there are no changes to pavement widths and/or the pavement marking configuration.

Provide the pavement marking layout plan to the Engineer prior to pavement removal operations and/or any pavement markings being disturbed. If any changes are needed, the Engineer will mark up a copy of the pavement marking layout plan and initial any changes. The Engineer will provide any markups and documented approval of the pavement marking layout plan to the Contractor within 10 calendar days of initial receipt.

The pavement surface must be clean and dry before applying pavement markings. Air blast to remove material that prevents pavement markings from adhering to the pavement surface. Remove debris and dead animals from the line track.

For solid lines, apply 4-inch lines, 6-inch lines, 8-inch lines, and 12-inch lines no greater than ¼ inch wider than the required width. Apply solid lines with no gaps or spaces. Apply a double line as two solid lines or one solid line and one broken line.

For new broken lines, apply 12½-foot-long lines. Leave a 37½-foot gap between new broken lines. Continue this 50-foot cycle of broken line and gap, as shown on the plans. Apply new lines at the required location within a lateral tolerance of 1 inch and no greater than 4 inches longer than the required length.

When applying centerline and lane lines on new construction, retrace at least five existing adjacent skips to match the existing pavement marking cycle.

Retrace existing pavement markings using lines equal to the width and length of the original markings. For existing 4-inch, 6-inch, 8-inch, or

12-inch-wide lines, retrace no greater than ¼ inch wider than the existing line. If existing lines exceed the nominal widths, ensure that the total line widths, existing and retraced, do not exceed 5 inches, 7 inches, 9 inches, and 13 inches.

For existing 12½-foot broken lines, place the retraced line to a longitudinal tolerance of no greater than 4 inches longer than the existing line. If existing lines exceed 12½ feet long, ensure that broken line lengths for existing and retraced lines do not exceed 13 feet.

Mix liquid materials during application. Do not thin materials. Uniformly apply pavement marking material at the rates shown in Table 811-1.

The Engineer will determine the application rates by dividing the quantity of material used by the length of the line placed. The Engineer may check application rates at start up and during work without prior notice to the Contractor.

Load pavement marking materials on the pavement marking machine without interfering with or delaying traffic. Operate striping equipment to prevent traffic from crossing the uncured markings. Prevent vehicles from being sprayed.

Position bead guns to direct beads into the line material and provide a uniform application of beads.

If applying markings in off-road areas open to traffic, including rest areas, roadside parks, and car pool lots, maintain traffic to prevent vehicles from crossing the uncured markings.

The Department does not require glass beads for waterborne pavement marking material for parking stalls and cross hatching if marking rest areas, roadside parks, and car pool lots. Beads are not to be placed in liquid shadow markings.

Apply pavement marking lines straight or in uniform curvature. Markings must be sharp and well defined and free of uneven edges, overspray, and other visible defects, as determined by the Engineer. Remove pavement markings outside the required tolerances and re-apply in the correct locations. Re-apply unprotected pavement markings damaged by traffic and remove tracked lines at no additional cost to the Department.

C. **Removal.** If required, remove existing pavement markings or in accordance with subsection 812.03.F.

When surface applying pavement markings on new concrete, remove the curing compound in accordance with subsection 812.03.F.

If removing existing special markings, including legends, symbols, crosswalks, cross hatching, and stop bars, in advance of placing new special markings, install the new markings within 5 working days of removing the existing markings.

When removing markings, collect and dispose of removed material.

D. **Application, Temperature, and Seasonal Restrictions.** Ensure that the material application rates in Table 811-1, the temperature and seasonal application restrictions in Table 811-2, and the additional requirements detailed in this subsection for specific materials are met when applying any material, unless directed by the Engineer. Document moisture testing and provide results to the Engineer.

1. **Waterborne.** The Engineer will not decide the suitability of specific days for the application of waterborne paint. Re-apply lines damaged by weather at no additional cost to the Department.

   The Contractor may place waterborne pavement markings immediately on new HMA pavement.

   For micro-surfacing projects, place waterborne pavement markings on the surface course before opening to traffic. Allow the surface to wear for at least 30 days or as determined by the Engineer before applying the second application of waterborne or a first application of sprayable thermoplastic.

Table 811-2:
Minimum Material Placement Temperature and Seasonal Restrictions[a]

Material	Minimum Air Temperature [b]	Minimum Pavement Temperature[c]	Date	
			Start	End
Waterborne	50°F	50°F	May 1	Oct. 15
Low temperature waterborne	35°F	35°F	Oct. 1	May 1
Regular dry	25°F	25°F	Oct. 1	May 1
Cold plastic tape with contact cement	60°F	60°F	May 1	Oct. 15
Cold plastic tape – primerless – without surface preparation adhesive	60°F	60°F	Jun. 1	Sept. 1
Cold plastic tape – primerless – with surface preparation adhesive	40°F	40°F	Apr. 15	Nov. 15
Thermoplastic	50°F	50°F	May 1	Nov. 1
Sprayable thermoplastic	50°F	50°F	Apr. 15	Nov. 15
Polyurea	40°F	40°F	Apr. 15	Nov. 15
Modified epoxy	40°F	40°F	Apr. 15	Nov. 15
Preformed thermoplastic	35°F	35°F	Apr. 15	Nov. 15

(a) See text for more detailed information.
(b) Temperature must meet minimum and be rising.
(c) Pavement must be dry.

Waterborne paint may be used outside the specified dates and temperatures only when approved by the Engineer.

2. **Low Temperature Waterborne.** If seasonal limitations prevent placement of waterborne paint, the Engineer may approve low- temperature waterborne paint.

   Wait at least 5 days after placing the pavement surface before applying low-temperature, waterborne pavement markings to new HMA wearing surface. The Engineer may waive the 5-day waiting period.

3. **Regular Dry Paint.** If seasonal limitations prevent the placement of waterborne paint, the Engineer may approve regular dry paint.

Wait at least 14 days after placing the pavement surface before applying regular dry pavement markings to new HMA wearing surface. The Engineer may waive the 14-day waiting period.

4. **Cold Plastic.** Prepare the pavement surface and apply the cold plastic tape in accordance with the manufacturer's specifications.

   Remove curing compound from new concrete surfaces before applying cold plastic tape. For pavements with two or more layers of existing overlay cold plastic marking material or any other non-compatible materials, remove the existing marking material before installing the new cold plastic markings.

   Install cold plastic tape symbols, legends, crosswalks, cross hatching, and stop bars, as shown on the MDOT Standard Plans, unless otherwise required in the plans.

   a. **With Contact Cement**. Apply contact cement recommended by the cold plastic marking manufacturer and approved by the Department. Mix contact cement during application. Do not thin the contact cement. Allow time for solvents to evaporate from the adhesive before applying the cold plastic marking. Apply the contact cement by a method recommended by the manufacturer and ensure that it is beneath the entire marking.

      Provide non-adhesive backed cold plastic for stop bars and crosswalks. Provide adhesive-backed cold plastic for all other special markings.

      Immediately after placement, roll transverse and special markings at least four times with a roller weighing at least 200 pounds. The Engineer will not require additional rolling for longitudinal applications if the equipment for installing the line is equipped with a roller.

   b. **Primerless – Without Surface Preparation Adhesive**. Ensure that the weather has been dry for at least 24 hours and that the pavement surface is dry before applying the primerless cold plastic tape marking. Clean the pavement surface using an air compressor with at least 185 cfm air flow and 120 psi. On all pavement surfaces, prevent damage to transverse and longitudinal joint sealers.

      Immediately after placement, roll transverse and special markings at least six times with a roller weighing at least 200 pounds. The Engineer will not require additional rolling for longitudinal applications if the equipment installing the line is equipped with a roller.

   c. **Primerless – With Surface Preparation Adhesive**. Use surface preparation adhesive on all primerless cold plastic tape as recommended by the manufacturer or as shown on the plans.

      Ensure that the weather has been dry for at least 24 hours and that the pavement surface is dry before applying the primerless cold plastic tape marking. Clean the pavement surface using an air compressor with at least 185 cfm air flow and 120 psi. On all pavement surfaces, prevent damage to transverse and longitudinal joint sealers.

      Immediately after placement, roll transverse and special markings at least six times with a roller weighing at least 200 pounds. The Engineer will not require additional rolling for longitudinal applications if the equipment installing the line is equipped with a roller.

5. **Thermoplastic.** The pavement must be free of excess surface and subsurface moisture that may affect bonding. The Engineer will not decide the suitability of specific days for the application of thermoplastic.

   Heat and apply the thermoplastic material within the temperature range recommended by the manufacturer.

6. **Sprayable Thermoplastic.** The pavement must be free of excess surface and subsurface moisture that may affect bonding. The Engineer will not decide the suitability of specific days for the application of sprayable thermoplastic.

   Heat and apply the sprayable thermoplastic material within the temperature range recommended by the manufacturer.

   On projects calling for 10,000 feet or less (per color) of sprayable thermoplastic pavement markings to be placed per workday, the Contractor has the option of placing two applications of waterborne paint instead of the sprayable thermoplastic pavement markings. The second application of waterborne is to be completed between 14 and 60 days after the initial application unless otherwise directed by the Engineer.

7. **Polyurea.** The pavement must be free of excess surface and subsurface moisture that may affect bonding. The Engineer will not decide the suitability of specific days for the application of polyurea.

   Surface preparation requirements for special and longitudinal polyurea pavement markings depend on surface conditions.

   Prepare new HMA surfaces and HMA surfaces open to traffic for 10 days or less with no oil drips, residue, debris, or temporary or

   permanent markings by cleaning the marking area with compressed air.

   Prepare new Portland cement concrete (PCC) surfaces and PCC surfaces free of oil drips, residue, debris, and temporary or permanent markings by removing the curing compound from the area required for pavement markings.

   Prepare existing HMA or PCC surfaces that do not have existing markings but may have oil drip areas, debris, or both, by scarifying the marking area using non-milling grinding teeth or shot blasting. The Engineer will allow the use of water blasting to scarify the marking area on PCC surfaces.

   Prepare existing HMA or PCC surfaces with existing non-polyurea markings by completely removing non-polyurea markings.

   Prepare existing HMA or PCC surfaces with existing polyurea marking and that may have oil drip areas, debris, or both, by using the following methods:

   a. For existing polyurea pavement markings, scarify the proposed marking area using non-milling grinding teeth or shot blast.

   b. Occasionally, existing polyurea pavement markings require complete removal, which will be determined by the Engineer.

8. **Modified Epoxy.** The pavement must be free of excess surface and subsurface moisture that may affect bonding. The Engineer will not decide the suitability of specific days for the application of modified epoxy.

   Surface preparation requirements for special and longitudinal modified epoxy pavement markings depend on surface conditions.

   Prepare new HMA surfaces and HMA surfaces open to traffic for 10 days or less free of oil drips, residue, debris, and temporary or

   permanent markings by cleaning the marking area with compressed air.

   Prepare new PCC surfaces and PCC surfaces free of oil drips, residue, debris, and temporary or permanent markings by removing the curing compound from the area required for pavement markings.

   Prepare existing HMA or PCC surfaces that do not have existing markings but may have oil drip areas, debris, or both, by scarifying the marking area using non-milling grinding teeth or shot blasting. The Engineer will allow the use of water blasting to scarify the marking area on PCC surfaces.

   Prepare existing HMA or PCC surfaces with existing non-modified urethane markings or non-modified epoxy markings by completely removing non-modified urethane markings or non-modified epoxy markings.

   Prepare existing HMA or PCC surfaces with existing modified urethane pavement markings or modified epoxy pavement markings and that may have oil drip areas, debris, or both, by using the following methods:

   a. For existing modified urethane pavement markings or modified epoxy pavement markings, scarify the proposed marking area using non-milling grinding teeth or shot blast.

   b. Occasionally existing modified urethane pavement markings or modified epoxy pavement markings require complete removal, which will be determined by the Engineer.

9. **Preformed Thermoplastic.** The pavement must be free of excess surface and subsurface moisture that may affect bonding. The Engineer will not decide the suitability of specific days for the application of preformed thermoplastic.

   Heat and apply the preformed thermoplastic material as recommended by the manufacturer. Feather all edges of the material with a putty knife while the preformed thermoplastic is still soft.

E. **Second Application.** If the contract requires a second application of permanent pavement markings, complete two applications regardless of initial pavement marking conditions. Complete the second application from 14 to 60 days after initial application in the same calendar year.

   The Contractor may apply the second application before the required 14 days if approved by the Engineer.

F. **Call Back Painting.** The Engineer will provide a prioritized list of locations and limits for call back pavement marking painting.

Begin call back painting work within 7 days of the Engineer's notification.

G. **Recessed Pavement Marking.** Install a recess (groove) in accordance with the pavement marking material manufacturer's installation instructions. All recessing configurations must be in accordance with the MMUTCD and MDOT's *Pavement Marking Standard Plans*.

1. **Grooving Concrete and Hot Mix Asphalt Pavement**. If there are no markings on the pavement, it is the Contractor's responsibility to layout and groove exactly where the permanent markings will be placed. If there are temporary painted pavement markings in the correct location, use these lines as a template for the grooving operation. If there are existing permanent pavement markings in place, remove them in accordance with subsection 812.03.F prior to grooving operations. The removal of any existing pavement markings will be paid for separately.

   Use equipment and methods approved by the manufacturer of the pavement marking material to be recessed for forming grooves in pavement surfaces. Dry-cut the grooves in a single pass using stacked diamond cutting heads on self-vacuuming equipment capable of producing a finished groove ready for pavement marking material installation.

   Ensure that the bottom of the groove has a fine corduroy finish. If a coarse tooth pattern results, increase the number of blades and decrease the spaces on the cutting head until the required finish is achieved.

2. **Placing Recessed Pavement Markings**. Place the pavement-marking material in clean and dry grooves within 24 hours of the grooves being made. Locate the groove so the entire marking can be placed within the groove.

H. **Raised Thermoplastic Rumble Strips.** If required on the plans, furnish and install raised thermoplastic rumble strips on pavement or as directed by the Engineer. Layout the thermoplastic rumble strips, prepare the pavement surface, and apply the rumble strips in accordance with sections 811 and 920 and the following:

1. Clean the pavement surface, making sure the pavement is dry and above the minimum temperature for thermoplastic placement in Table 811-2.
2. Apply the thermoplastic in accordance with the manufacturer's recommendations and as shown in MDOT's *Pavement Marking Standard Plans*.
3. Apply glass beads as recommended by the thermoplastic manufacturer.

I. **Raised Pavement Marker (RPM) Removal.** Remove RPM with equipment approved by the Engineer. During removal, do not disturb pavement more than 3 inches below the surface or more than 3 inches from the perimeter of the marker casting. The Engineer will stop marker removal if damage to the pavement exceeds these limits.

The Engineer will require patching, regardless of milling requirements, unless the Engineer determines that damaged areas do not pose a hazard to traffic. Use an HMA mix approved by the Engineer to patch concrete and HMA pavements that will receive an HMA overlay.

Use a prepackaged, hydraulic, fast-set material for patching structural concrete from the Qualified Products List for patching concrete pavement.

Patch concrete pavement in accordance with the patch material manufacturer's specifications.

Patch HMA pavement, not requiring overlay, with the epoxy adhesive used to attach raised pavement markers to the pavement.

Clean and dispose of debris from RPM removal and patching operations.

J. **Wet Reflective Liquid Applied Pavement Markings.** Furnish and install WR optics and liquid applied pavement marking materials. Place the binder, beads, and WR optics in accordance with the manufacturer's recommendations and sections 811 and 920.

K. **Guide Line Pavement Markings.** Provide all labor, material, and equipment necessary to prepare pavement surface and layout and apply solid or dotted retroreflective guide line pavement markings. When using dotted guide lines to delineate vehicle movements, the guide lines must be recessed. Prepare pavement surfaces by using the following methods:

1. Remove all residue and debris resulting from the preparation work. Control and minimize airborne dust and similar debris generated by surface preparation and cleanup to prevent a hazard to motor vehicle operation or nuisance to adjacent property.
2. Do not damage transverse and longitudinal joint sealers on hot mix asphalt and PCC surfaces when performing removal and cleaning work.
3. Preformed tape markings must be ready for traffic immediately following surface preparation, application and tamping, and markings of other materials must be adequately protected until they can be crossed by traffic without tracking.
4. Replace or repair nonconforming material to the satisfaction of the Engineer, and at no additional cost to the Department.

811.04. MEASUREMENT AND PAYMENT

A. **General.** The Engineer will not measure the skips in dashed lines. Unless otherwise included in the contract, the cost of traffic control and mobilization is included in the unit prices for other pavement marking placement pay items.

The cost of collecting and disposing of residue generated by the removal of pavement markings and curing compound is included in the unit prices for removal pay items.

The cost of WR optics is included in the unit prices for the applicable pavement marking material.

The Department will not pay separately for the contact cement and adhesives for longitudinal lines, legends, symbols, crosswalks, cross hatching, or stop bars.

The Department will not pay for markings placed by equipment operated at speeds higher than the certified speed.

The Department will not assess liquidated damages if the 5-day waiting period for placing low-temperature, waterborne paint is in effect and the project is complete. The Department will not assess liquidated damages if the 14-day waiting period for regular dry paint is in effect and the project is complete.

Permanent pavement marking materials, temporary retroreflective pavement markings required for traffic control, removal of curing compound, removal of existing permanent pavement markings, and scarification of pavement markings will be paid for separately using the appropriate pay items.

B. **Seasonal Limitations.** The Engineer will apply price adjustments as required by the contract only for the quantity of regular dry or low-temperature waterborne substituted for waterborne paint and placed outside seasonal and temperature limitations. The adjustment applies only to projects that have completion dates after October 1 or have approved extensions of time without liquidated damages beyond

October 1. Contractors who are in liquidated damages between October 2 and April 30 are not eligible for the price adjustment.

C. **Sprayable Thermoplastic.** When two applications of waterborne pavement markings are substituted for a single application of sprayable thermoplastic due to placing 10,000 feet or less (per color) per work day, the two applications of waterborne are paid for as a single application of sprayable thermoplastic under the sprayable thermoplastic pay items in the contract.

D. **Pavement Marking Removal.** The Engineer will measure the full removal of special markings based on MDOT's *Pavement Marking Standard Plans.* The Department will pay for partial removal of special markings based on the dimensions of the actual removal area. If full removal of pavement markings is required, the unit prices for **Rem Spec Mrkg** or **Pavt Mrkg, Longit, 6 inch or Less Width, Rem**, and **Pavt Mrkg, Longit, Greater than 6 inch Width, Rem** include the cost of the removal in accordance with subsection 812.04.N.

If the Contractor removes multiple layers of pavement marking materials, the Department will not pay separately for material removed beyond the first layer.

E. **Curing Compound Removal.** The unit price for **Rem Curing Compound** includes the cost of preparing new PCC for marking application by removing the curing compound. Measurement will be based on MDOT's *Pavement Marking Standard Plans*.

F. **Scarification.** The unit price for **Scarification, for Polyurea Spec Mrkg** and **Scarification, for Modified Epoxy Spec Mrkg** includes the cost of preparing the pavement surface via shot blasting or grinding with non-milling teeth for new pavement markings where pavement markings of the same type are existing. Measurement will be based on MDOT's *Pavement Marking Standard Plans.*

G. **Recessing.** The unit price for **Recessing Pavt Mrkg, Longit; Recessing Pavt Mrkg, Transv** and **Recessing Pavt Mrkg, Guide Line** includes the cost of laying out the exact location of the

markings and all work as required to prepare (groove) the pavement surface for recessed pavement markings.

H. **Thermoplastic Rumble Strips.** The Engineer will measure each length of 6-inch by 3/8-inch thermoplastic material, both transverse and longitudinal, to determine the total length of **Pavt Mrkg, Thermopl, Rumble Strip** for payment.

I. **Guide Lines**. The unit price for **Pavt Mrkg, Ovly Cold Plastic, inch**, **Dotted Turning Guide Line, (color)** and **Pavt Mrkg, (material), inch**, **Dotted Thru Guide Line, (color)** will be for the footage of pavement marking material placed, not the full path of the turning guide line. Solid guide line pay items are for the full path of the guide line.

J. **Material Deficiency.** The Engineer will compute the quantity of pavement marking material and glass beads applied per unit of measurement at the end of each work day. The Engineer may include an applied length of less than 10 miles in the next day's measurement. The Engineer will determine the material usage based on field measurements and the required application rate specified in Table 811-1.

The Department will reduce the unit price for pavement marking material for material shortages in direct proportion to the deficient material quantity, up to 6%. If the daily deficiency of pavement marking material, or beads, is greater than 6%, the Department will consider the day's work unsatisfactory and will direct the Contractor to reapply the day's markings to the thickness required by the contract at no additional cost to the Department.

K. **Raised Pavement Marker Removal.** The unit price for **Rem Raised Pavt Marker** includes the cost of the required patching material.

811.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-811.05.01	Pavt Mrkg, Rem	Linear Foot (LF)
MDOT-811.05.02	Pavt Mrkg, Waterborne, Yellow w/ Reflective Beads	Square Foot (SF)
MDOT-811.05.03	Pavt Mrkg, Black	Square Foot (SF)
MDOT-811.05.04	Pavt Mrkg, Waterborne, White w/ Reflective Beads	Square Foot (SF)
MDOT-811.05.05	Pavt Mrkg, Waterborne, Yellow w/ Reflective Beads - Bid Alt 1	Square Foot (SF)
MDOT-811.05.06	Pavt Mrkg, Black - Bid Alt 1	Square Foot (SF)
MDOT-811.05.07	Pavt Mrkg, Waterborne, White w/ Reflective Beads - Bid Alt 1	Square Foot (SF)

END OF ITEM MDOT-811

Item MDOT-816 Turf Establishment

816.01 DESCRIPTION

This work consists of conducting soil tests, preparing the soil, and placing sod or seed and mulch to permanently stabilize disturbed areas as shown on the plans.

A. **Definitions.**

The following terms apply to this section.

Broadleaf Weed. Any dicotyledonous weedy plant. Broadleaf weeds include, but are not limited to, dandelion, clovers, thistles, and ragweed.

Compost. Mature, stabilized, humus-like material derived from the aerobic decomposition of yard clippings, leaves, and brush with a diameter less than 4 inches.

Dormant Seeding. Seeding placed in late November and December when plant growth ends for the season. Seeds are placed on unfrozen ground and mulched to lie dormant over the winter and germinate the following spring.

Friable. Easily crumbled or pulverized soil.

Friable Condition. Soil in a friable condition is a crumbled, pulverized, worked-up, loosened, or cultivated soil that is free of lumps and clods detrimental to seeding and sodding operations.

Humus. Brown or black material formed by the decomposition of vegetable or animal matter; the organic portion of soil, essential to fertility.

Hydromulching. Spraying mulch combined with water and mulch- anchoring material onto a prepared seed bed.

Hydroseeding. Spraying seed and fertilizer combined with water onto a prepared seed bed.

Muck. Organic matter consisting of decomposed plant material accumulated under conditions of excessive moisture. If organic remains are not identifiable as plant form, the material is considered muck.

Mulch. Material placed over seeding to improve germination by conserving moisture, moderating the soil temperature, and protecting the seed and soil from water and wind erosion.

Mulch Anchor. Glue-type material sprayed over mulch to hold it in place.

Peat. Organic matter consisting of partially decayed plant material accumulated under conditions of excessive moisture. If organic remains are identifiable as plant form, the material is considered peat.

Soil Test. Analysis report of soil nutrient content particle size, pH levels, and organic matter.

Soil Tracking. Horizontal grooves on exposed slopes 1:3 or greater parallel to the contour of the land using tracked construction equipment.

Target Weeds. Weeds the Engineer identifies for removal by spraying or other methods. Target weeds include any plant not included in the specified seed mix.

Turf Reinforcement Mat. Three-dimensional matrix of synthetic or a composite of synthetic and natural materials that is used to permanently control erosion.

816.02 MATERIALS

Provide materials in accordance with the following sections:

Compost…… 917
Topsoil…….....917
Fertilizer……. 917
Seed…….....917
Sod…… 917
Mulch…… 917
Mulch Anchoring 917
Mulch Blankets… 917
Turf Reinforcement Mat 917
Weed Control…… 917
Water……911

816.03 CONSTRUCTION

Establish turf in accordance with this section, the MDOT Soil Erosion and Sedimentation Control Manual, and as directed by the Engineer.

A. **Topsoiling.** Before placing topsoil, prepare the foundation. Provide, place, and spread humus bearing topsoil, compost, or both. Use topsoil from within the project limits or from off-site sources meeting the requirements in subsection 917.06. Obtain the Engineer's approval for topsoil placement prior to seeding.

1. **Preparation of Earth Bed.** Seven to 10 days before preparing earth bed, including areas previously mulched or rye seeded for temporary erosion control, kill existing vegetation by spraying with the non-selective herbicide containing glyphosate.

   Construct the earth bed to the required grade and trim.

2. **Placing Topsoil**. Place topsoil meeting the requirements in subsection 917.06. Cover areas requiring seeding or sodding with topsoil, compost, or both, except for slopes constructed of topsoil, muck, or peat.

   Spread topsoil, compost, or both on the prepared areas at least 3 inches deep. Pulverize large clods and lumps. Rake out rocks with a diameter greater than 2 inches, roots, litter,

and deleterious material. Dispose of raked-out material in accordance with subsections 205.03.A.3 and 205.03.P.

Incorporate topsoil and compost into the upper 3 inches of the prepared earth bed. Do not work topsoil or compost if wet. Perform soil tracking prior to seeding on slopes steeper than 1:3. Leave horizontal soil impressions from equipment across the face of the slope, as required by Engineer and noted in the MDOT Standard Plan R-96 series for soil erosion control measures.

3. **Excavated Topsoil or Salvaged Topsoil.** The Engineer will direct stockpiling excavated or salvaged topsoil within the right-of-way. Maintain the stockpile in a weed-free condition during the entire project duration.

B. **Chemical Fertilizer Nutrient**. Not Used.

C. **Seeding.** For each species, provide seed varieties selected from the Qualified Products List. Do not broadcast or hydroseed in conditions that would prevent seed placement as required. Apply turf and specialty seed mixtures in accordance with the mix ratios and seed rates in Table 816-1 and Table 816-2.

Table 816-1: General Roadside Seed Mix Selection Guide

Turf Seed Mixture		Soil Type	General Location	Seed Rate	Salt Tolerance
TDS	turf dry sandy	Dry sandy to sandy loam	Rural or urban	220 lb/acre	Low to medium
THV	turf heavy soil	Heavy	Rural	220 lb/acre	Medium to high
TUF	turf urban freeway	All types	Urban freeways, blvds., service roads, city streets	220 lb/acre	Medium to high
TGM	turf medium to heavy soil	Medium to heavy	All	220 lb/acre	Low
THM	turf loamy to heavy	Loamy to heavy	Residential and business turf	220 lb/acre	Low to medium

Table 816-2: Temporary Seeding Mixtures

Seed Mixture		Soil Type	General Location	Seed Rate
CR	cereal rye, <6 mos	All	All	70 lb/acre
TSM 6/24	temporary seeding, 6–24 months	All	All	100 lb/acre
TSM 24+	temporary seeding, >24 months	All	All	200 lb/acre

1. **Permanent Seeding**

   a. **Sowing.** When the seed bed has been properly graded, weeds have been eliminated, and the seed bed has been raked, harrowed, and tracked and is in a friable condition, sow seed with or following the application of fertilizer. Sow seed before applying mulch. Sow or resow the seed mixture, providing uniform coverage at the rate specified in Table 816-1 or Table 816-2.

   Sow using mechanical drills, hydroseeders, or by broadcasting. In areas with 1:4 slopes or flatter, use mechanical drills.

   The Department will allow hydroseeding on slopes steeper than 1:4 as approved by the Engineer.

   Empty the hydroseeder tank within 1 hour of introducing the seed and/or fertilizer to the tank. Dispose of tank contents that remain in the tank mixed with hydroseeder for longer than 1 hour.

   Broadcast in areas requiring resowing or in areas not accessible to a drill or hydroseeder.

   The Engineer will visually inspect areas sown for uniformity of application. Resow areas that do not have an average of two seeds per square inch at no additional cost to the Department.

   b. **Setting the Seed.** Lightly compact or rake areas sown by broadcast method to incorporate the seed into the top ½ inch of the topsoil. Immediately after setting the seed, mulch in accordance with subsections 816.03.E and 816.03.F.

2. **Temporary Seeding.** Obtain the Engineer's approval for temporary seeding. Place temporary seed only for erosion control or temporary soil stabilization. Do not temporarily seed slopes 1:3 or steeper after placing topsoil; permanently seed these slopes. Sow temporary seed in accordance with subsection 816.03.C.1. Before project completion, replace temporary seeding with permanent seeding as shown on the plans or directed by the Engineer.

3. **Dormant Seeding.** The Engineer will allow dormant seeding in limited areas. Obtain the Engineer's approval prior to dormant seeding. Dormant seed in accordance with subsection 816.03.C.1.

4. **Seasonal Limitations**

   a. **Permanent Seeding.** Permanently seed the following locations during the specified periods:

      i. **Southern Lower Peninsula.** South of the north boundary of Township 20 North; April 15 through October 10.

      ii. **Northern Lower Peninsula.** North of the north boundary of Township 20 North; May 1 through October 1.

      iii. **Upper Peninsula.** May 1 through September 20.

b. **Dormant Seeding.** Dormant seed the following locations during the specified periods:

i. **Southern Lower Peninsula.** South of the north boundary of Township 20 North; after November 15 but not on frozen ground.

ii. **Upper Peninsula and Northern Lower Peninsula**. North of the north boundary of Township 20 North; after November 1 but not on frozen ground.

c. **Temporary Seeding.** Temporary seed in accordance with the seasonal limitations specified in subsection 816.03.C.4.a.

5. **Inspection.** The Engineer will inspect the seeded turf to ensure that the end result is well established, growing, and vigorous and contains the species required by the seeding mixture.

The Engineer will approve slopes as the Contractor completes permanent restoration on cut slopes, embankment slopes, or portions of slopes. The Engineer will consider each cut or embankment slope on each side of the roadway separately for approval.

Complete weed control in accordance with subsection 816.03.I.

D. **Sodding.** Not Used.

E. **Mulching**. Not Used.

F. **Mulch Anchoring.** Not Used.

G. **Mulch Blankets.** Not Used.

H. **Water.** Provide and apply water in accordance with section 911 to sodded and seeded areas at the required rates. The Engineer may adjust watering based on the season and weather conditions.

1. S**od**

a. Water the earth bed with at least 3½ gallons per square yard before laying the sod;

b. Apply at least 5 gallons per square yard after placing the sod;

c. Apply an additional 5 gallons per square yard within 24 hours after placing the sod; and

d. Apply 3½ gallons per square yard of sod, five times at 3- to 5-day intervals.

2. Seed

a. Water seeded areas at 3½ gallons per square yard or as needed; and

b. Continue watering regularly after germination begins in order to prevent seeds and seedlings from drying out.

I. **Weed Control.** Not Used.

J. **Mowing.** Maintain turf at 6 inches or less during construction and until final acceptance. Mowing to be paid for as Weed Control.

K. **Acceptance.** Turf will be accepted when there is sufficient growth across 90% of the restored area to establish the turf bed and prevent soil erosion.

816.04 MEASUREMENT AND PAYMENT

A. **Compost.** Not Used.

B. **Topsoil.** The Engineer will measure Topsoil Surface, Salv, inch in place.

C. **Fertilizer, Chemical Nutrient.** Not Used.

D. **Sod.** Not Used.

E. **Mulching Material.** Not Used.

F. **Turf Reinforcement Mat.** Not Used.

G. **Water, Sodding, and Seeding.** Water shall be incidental to this Specification.

H. **Weed Control.** Not Used.

I. **Seeding, Mixture.** The Engineer will measure Seeding, Mixture of the type required, in pounds of seed applied.

816.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-816.05.01	Seeding, Mixture TUF	Pound (LB)
MDOT-816.05.02	Topsoil Surface, Salv, 4 Inch	Square Yard (SY)
MDOT-816.05.03	Seeding, Mixture TUF – Bid Alt 1	Pound (LB)
MDOT-816.05.04	Topsoil Surface, Salv, 4 Inch – Bid Alt 1	Square Yard (SY)

END OF ITEM MDOT-816

Item MDOT-818 Electrical

818.01 DESCRIPTION

This work consists of providing operating electrical units; removing, salvaging, or disposing of existing electrical components; excavating, backfilling, and restoring the site in accordance with section 816; and disposing of waste excavated materials. Complete this work in accordance with this section, sections 819 and 820, and the contract. For items not specified in section 819 or 820 or the contract, complete the work in accordance with the requirements of the NEC, the NESC, MIOSHA, and the Michigan Department of Licensing and Regulatory Affairs (MDLARA).

Provide personnel who are qualified and experienced in performing the required work. Provide a licensed journeyman electrician supervisor on-site during installation and electrical construction.

818.02. MATERIALS

Provide material in accordance with the following sections:

Granular Material Class II 902

Coarse Aggregate 17A..... 902

Conduit……..... 918

Electrical Grounding System 918

Electrical Wire and Cable..... 918

Direct Burial Cable..... 918

Equipment Grounding Conductor 918

Handholes……..... 918

Wood Poles……..... 918

Concrete, Grade 3500..... 1004

A. Conduit

1. **Direct Burial Application.** Provide a smooth surface conduit of one of the following types for direct burial applications:
   a. Galvanized steel conduit;
   b. Smooth-wall, Schedule 80 rigid (PVC);
   c. Smooth-wall, coilable, Schedule 80 (polyethylene [PE]); or
   d. Rigid fiberglass.
2. Provide Schedule 80 conduit for traffic signal, ITS, and freeway lighting work.
3. **Jacking and Boring Application.** Provide Schedule 80 PVC or Schedule 80 PE conduit for jacking and boring operations.
4. **Directional Boring Application.** Provide Schedule 80 coilable PE conduit for directional boring.

5. **Encased Conduit Application.** Provide Schedule 80 conduit for encased conduit and provide Grade 3500 concrete made with 17A coarse aggregate in accordance with section 1004.

6. **Conduit on Structure Application.** Provide Schedule 80 PVC or rigid fiberglass conduit on structures.

B. **Conductors.** Provide the number of stranded copper conductors for overhead and underground conductors shown on the plans.

C. **Bracket Arm, Clamp On.** This work consists of completing one or more of the following work types at locations shown on the plans:

1. Furnishing and installing a 6-, 9-, 12-, 15-, or 18-foot clamp on bracket arm.

2. Removing and disposing of an existing 6-, 9-, 12-, 15-, or 18-foot clamp on bracket arm.

As applicable, this work includes removal or installation of clamp-on bracket arm of the size specified on the plans and any associated materials required to ensure a complete removal or installation, as specified for a location.

Fabricate the bracket arm truss tubes from 2⅜-inch OD by 0.120-inch-thick steel tubing meeting the requirements of ASTM A500/A500M for Grade B steel and subsection 105.10. Weld to a ⅜-inch-thick steel mounting plate meeting the requirements of ASTM A36/A36M.

Weld ½- by 2-inch flat bar meeting the requirements of ASTM A36/A36M between bracket arm tubes to form the truss. Weld ¼-inch flat bar steel gussets between arm tubes and mounting plate. Complete welding in accordance with AWS D1.1 and the contract.

Hot dip galvanize the bracket arm, all brackets, and hardware after fabrication and welding according to ASTM A123/A123M and ASTM A153/A153M where applicable.

D. **Steel Pole Mount.** Use U-bolts meeting the size requirements below to attach bracket arms to steel poles. Use hex nuts, flat washers, and lock washers to secure U-bolts. U-bolts and hardware must meet the requirements of ASTM A36/A36M steel.

Use ⅝-inch rod U-bolts for pole diameters equal to or greater than 8½ inches but less 9⅛ inches. Use ¾-inch rod U-bolts for pole diameters equal to or greater than 9⅛ inches and equal to or less than 10¼ inches.

E. **Wood Pole Mount**. Fabricate the pole-mounting plate from ⅜-inch-thick steel plate meeting the requirements of ASTM A36/A36M and weld gussets to the arm tubes. There must be one plate per arm tube. Each plate must incorporate two 0.562-inch-diameter holes and one 0.687- by 1.50-inch keyhole for lagging to the wood poles.

818.03. CONSTRUCTION

Contact the MDLARA for electrical service inspection prior to energizing services.

A. **Conduit.** Build straight conduit runs. If the contract requires sweeps, use the largest radius that will fit the work space available for each sweep. Do not install more than 360 degrees of bends per conduit run between junction boxes per NEC.

Provide conduit fittings and use methods of joining conduits, including conduit cement, in accordance with current NEC methods. If the NEC does not clearly describe the method, install the conduits in accordance with the manufacturer's recommendation. Obtain the Engineer's approval of installation methods before beginning work.

Attach end bells on the ends of conduits entering handholes to prevent damage to the cable.

Install continuous coilable conduit between handholes.

For conduit not terminating in structures such as manholes, handholes, or foundations, extend the conduit 2 feet beyond pavement limit unless otherwise required. Plug unoccupied conduit.

Verify that new conduit inserted into existing manholes or handholes does not interfere with racking, training of cables, or both. Do not disturb existing cables.

1. **Bends.** Bend conduit to the radii specified in the current NEC. For conduit entering foundations or cable pole envelopes, provide conduit with factory bends.
2. **Excavation.** Excavate the conduit trench to provide an earth cover of at least 30 inches over the finished conduit.
3. **Drainage.** Grade the trench to provide drainage to handholes.
4. **Grades.** Stake conduit grades at no greater than 50-foot intervals or as directed by the Engineer. Create a grade that slopes at least
   4 inches over 100 feet to the lowest manhole or handhole or from the middle of the conduit run toward both holes.
5. **Backfill.** Tamp the bottom of the trench to produce a smooth, flat, or gently sloping surface before placing the conduit. Backfill trenches outside the roadbed with excavated material, suitable for backfill, as determined by the Engineer. If excavated material is unsuitable, backfill the trenches with Class II granular material in accordance with section 204.

   Backfill trenches within the limits of the roadbed with Class II granular material in accordance with section 204.
6. **Supports.** Provide support for conduit running through holes built over or into existing duct. If ducts are built into an existing handhole, build a 4-inch tapered pocket into the wall. Build new service ducts into existing handholes without interfering with cable racking. Install required inserts.
7. **Clearances.** Do not allow conduit or concrete encasement to contact obstructions. Provide a vertical clearance of 9 inches, except provide at least 12 inches of clearance for conduit running parallel to water lines, gas mains, and other underground structures not part of the electrical system.

The Engineer and the owner of the obstruction will determine the method of protection if the Contractor cannot provide the required 12-inch clearance.

Exposed Conduit. For high voltage lines, minimum clearance must follow MIOSHA, NESC, and utility standards.

8. **Clearing.** After installing conduit runs, pull a mandrel 12 inches long, or shorter for conduit runs with bends, and with a diameter ½ inch smaller than the conduit. Attach a swab or cleaning device designed to clear the conduit to the mandrel. Notify the Engineer before performing clearing work.

9. **Encased Conduit.** Encase conduit runs in Grade 3500 concrete. Space adjacent conduits at least 1 inch apart and fill the space with concrete. Provide a conduit encasement with at least 3 inches of concrete around the conduit. If steel reinforcement is required, separate the reinforcing bars from the conduits with 2 inches of concrete. Provide at least 3 inches of concrete cover between the reinforcing bars and the surface of the encasement. Stagger conduit joints vertically.

   Use concrete, plastic, or bituminized fiber as separators, spacers, blocks, or supports that will remain in the finished concrete encasement. If installing 20-foot lengths of conduit, place spacers no greater than 7 feet apart. If installing 10-foot lengths of conduit, place spacers no greater than 5 feet apart.

   Prevent the conduit bank from floating after concrete placement by anchoring the bank to stakes at intervals no greater than 10 feet apart in firm soil and no greater than 5 feet apart in loose soil.

   Verify that the concrete fully encases the conduit.

   a. **Tier by Tier Method.** Grade the trench and place a foundation of concrete at least 3 inches thick in the bottom of the trench. If steel reinforcement is required, place the concrete at least 5 inches thick with reinforcing bars in place. Lay the bottom tier of conduits, separated by spacers. Fill the space between conduits with concrete and cover the conduits to the height of the next conduit tier. Construct succeeding tiers as specified for the first tier. Provide continuous placement of successive tiers of conduit with interruptions no greater than 45 minutes.

   b. **Build-Up or Monolithic Methods**. Grade the trench and place masonry supports at intervals of 3 to 5 feet or a foundation of concrete at least 3 inches thick in the bottom of the trench. If steel reinforcement is required, place the concrete at least 5 inches thick with the reinforcing bars in place. Place the conduit using plastic or concrete separators to erect a rigid, self-supporting structure of conduit. Place the concrete to fill the spaces between the conduits completely, without damaging or displacing them.

      Notify the Engineer prior to encasing the conduit in concrete.

      Place a coupling on the ends of conduit and install a removable plug. Sheet and brace the trenches as required. Support pipes or other structures exposed in the trenches as required to prevent damage.

10. **Directional Bore.** Bore by augering or jacking a steerable rod and pulling back a cone reamer that expands the soil that cuts a hole to the required diameter. Use a reamer with a diameter no greater than 2 inches larger than the conduit, as shown on the plans.

    The Contractor may use a drilling fluid of water and bentonite in directional drilling. The Contractor may use a polymer for lubrication in the drilling fluid.

    Place directional bore or drill equipment and supplies so they do not interfere with traffic or with the use of adjacent property. Locate equipment and supplies a minimum distance from the edge of pavement as directed by the Engineer. Place access pits in the location of handholes at the boring termination points, as shown on the plans or directed by the Engineer.

11. **Jacking and Boring**

    a. **Compaction Auger (packer, expander).** Auger a rotating stem under the roadway and then pull back a series of graduated cones that displace the soil to obtain the required diameter.

    b. **Hydraulic Push Rods or Stem (pipe puller, packer).** Push rods or stems under the roadway with a hydraulic ram and pull a series of graduated cones that displace the soil to obtain the required diameter.

    c. **Other Methods.** The Engineer may approve other jacking and boring methods before construction. Do not jet or use water or air ahead of the casing.

       The Contractor may use air rams longitudinally in the right-of-way but under roadways only if approved by the Engineer.

       Before jacking and boring, excavate a starter alignment trench to the elevation of the proposed conduit. Excavate a length of level trench at least 15 feet long for trenches up to 4 feet deep, and increase the trench length 5 feet for each additional 1 foot of depth.

       Use guide rails, sills, or other positive alignment devices to start the crossing. Restrain drive rods against horizontal and vertical movement.

       If using heads to develop an opening with a diameter greater than 2 inches, develop openings by increasing the head size in 1 inch increments.

       If the highway is super-elevated, start the bore from the lower side of the pavement.

       The Engineer will determine whether conditions warrant the use of sheeting and bracing. Use sheeting and bracing for boring as directed by the Engineer if access pits are located within the 1:1 slope from the edge of paved surfaces or back of curbs.

       Place access pits in the location of handholes at the boring termination points, as shown on the plans or directed by the Engineer.

       Provide the bore and jack record sheet or log if requested by the Engineer.

Control groundwater entering the excavation from seepage layers and lenses or pockets of saturated material from inside the excavation using drainage, bailing, pumping, or other methods. Do not remove or disturb adjacent soil while draining the groundwater.

If ordinary methods of drainage prove unsatisfactory, as determined by the Engineer, drain excavations as required.

12. **Record Drawings.** Within 5 days after completing conduit work or installing working cables, provide a record drawing to the Engineer. Show deviations from the original plans. Measure the lengths from the inside walls of the handholes and the center of post foundations and cable poles.

B. Electrical Wire and Cable

Permanently tag wires and cables in manholes, handholes, and cabinets at the points of entrance, exit, splicing, and termination. Label new and affected wires and cables to indicate the source and use of each where above grade. Tag wires and cables in manholes and handholes with a stamped brass tag.

Provide wires and cables with an additional length of at least 10 feet in each manhole and handhole.

Seal cable ends where the plans show coiling of cable.

Cut and remove cables within handholes and manholes for abandoned underground cables as shown on the plans.

Permanently label detector wiring harnesses at the cabinet terminal strip with the source and use.

Do not install service entrance conductors in handholes or vaults containing other wires or cables.

Do not splice signal cables or interconnect cables for traffic signals unless indicated in the plans.

C. **Direct Burial Conductors.** Provide and install direct burial single conductors.

1. **Approval.** Unless otherwise specified in the contract, the Department is the agency responsible for maintaining direct burial conductor facilities. Provide certified test reports to the maintaining agency upon request.
2. **Installation.** Install direct burial conductors as shown on the plans and in accordance with the manufacturer's recommendations. Do not drag conductors on the ground. Do not splice conductors underground. Install conductors in continuous runs between manholes, handholes, or foundations.
3. **Location.** Install direct burial conductors parallel to the edge of pavement, along the shoulder edge, clear of guardrail locations. Place conductors in a straight line between visible reference points such as handholes or light standards.
4. **Excavation.** After compacting the subbase in the shoulder area to at least the elevation of the top of the base course, cut a trench along the shoulder edge for placement of the conductors.

Remove rocks or other sharp objects from the trench. Lay the conductors in the trench.

Install marking tape from 6 to 18 inches above underground conduit or cable. Do not install marking tape above jacked and bored conduit.

The Department will provide the marking tape.

Provide 3 feet of cover over direct burial cable installed outside the shoulder.

5. **Conductors Installed In Conduit.** If installing direct burial conductors in conduit, use clean conduit, free of rough spots.

   Avoid damage to insulation and conductor jackets during installation.

   When required, use lubricating compounds approved by the conductor manufacturer. Use non-injurious lubricants listed by nationally recognized testing laboratories on conduits, conductors, insulations, or jackets.

   Provide slack in each run of cable.

   Group multiple conductors trained through a box, manhole, or handhole, by circuit. Bundle them using cable ties, and support them to reduce pressure or strain on conductor insulation. Bend wire and cable in accordance with the manufacturer's recommended bending radius during installation and in permanent placement.

   Use a cable-pulling apparatus with no sharp edges or protrusions.

6. **Testing.** Test direct burial conductors for continuity, shorts, and grounds after installation and backfill. Replace conductors that fail field tests with new conductors at no additional cost to the Department.

D. **Equipment Grounding and Bonding.** Provide and install grounding electrode conductors to provide a continuous grounding electrode system. Install grounding electrode conductors and connect to light standard bases, strain poles, pedestal bases, span wires, concrete-encased electrodes, ground rods, and service disconnects. For traffic signals, all equipment listed above that is associated with a single cabinet must be bonded to a continuous connection from grounding electrode system. Do not use equipment grounding conductors to provide continuity of the grounding electrode system. Install equipment grounding conductors in the same raceway or trench as the current-carrying conductors and connect to the ground bus at the electrical source and to the grounding termination at the utilization equipment.

   If installing conductors directly in earth with no conduit protection, the Contractor may use a bare conductor. Install the conductor at the same depth as a conductor installed in conduit.

   If installing the conductors in conduit, use an insulated conductor, color-coded green in accordance with subsection 918.04.A. Do not damage the conductor during installation.

E. **Handholes**. Provide and install, remove, salvage, reconstruct, abandon, or adjust handholes, including covers and fittings as shown on the plans.

If the plans show existing cables maintained in new handholes, break and remove conduit and concrete encasements to the walls of the new handhole. Extend existing cables, train, rack, and support on the walls of the handhole.

1. **Remove or Abandon.** Remove handholes completely or abandon in accordance with section 204.
2. **Adjust.** Adjust handholes in accordance with section 403.
3. **Reconstruct.** Reconstruct handholes in accordance with section 403. Use existing frames and covers unless otherwise directed by the Engineer.
4. **Installation**. Ensure that handholes are flush with the pavement surface and 1 inch above grade outside paved areas. Install the frame and cover flush with the top of the handhole.

   Use CIP or precast reinforced concrete handholes.

   Make the inner surface of reinforced handholes smooth. Sandblast castings. Cast handholes free of pouring faults, blow holes, cracks, and other imperfections. Cast handholes that are sound, true to form and thickness, clean, and finished.

   Provide and install cable racks and hooks.

   Plug unused conduit entrances and conduit openings for future use by others with removable plastic plugs or other plugs approved by the Engineer.

   Remove rubbish, construction debris, and water from handholes. Grout conduits from outside the handholes to inside the handholes.
5. **Excavation.** Excavate to the diameter and depth for installing handholes at locations shown on the plans.
6. **Drainage.** Cast drain holes at the bottom of the handhole. Provide drainage of handholes installed over underground conduits and on bridge decks.
7. **Backfill.** Install the handhole on Class II granular material. The Engineer will determine whether excavated material meets the backfill requirement. Use Class II granular material if the Engineer determines that excavated material does not meet the backfill requirement.

F. Electrical Service Requirements

1. **Unmetered Service.** Provide NEMA type 4X service disconnecting means with stainless steel enclosures, unless otherwise required. The Department will provide means for padlocking the operating handles in the open or closed position. If directed by the Engineer, run conduit on the outside of the pole. Support the conduit using two-hole galvanized support brackets, spaced no greater than 3 feet apart. Bond the conduits and equipment as required by the NEC, utility company, and the contract. Use waterproof metal elbows with removable covers to enter and exit service disconnects and controllers.
2. **Metered Service**. Provide NEMA type 4X service disconnecting means with stainless steel enclosures, unless otherwise required. The Department will provide means for padlocking the operating handles in the open or closed position. On wood poles, connect the meter socket to

the service disconnect using at least 1½-inch-diameter Schedule 80 PVC or galvanized metal conduit. On steel poles, connect the wiring between the meter socket and the service disconnect on the inside of the pole. If directed by the Engineer, run conduit on the outside of the pole. Support the conduit using two-hole galvanized support brackets, spaced no greater than 3 feet apart. Bond the conduits and equipment as required by the NEC, utility company, and the contract. Use waterproof metal elbows with removable covers to enter and exit meters, service disconnects, and controllers.

3. **Electrical Service Removals**. Contact the local power company shown on the plans to coordinate removal of metered service and power feed. Perform removal work in accordance with the NEC, the contract, and the local power company standards.

G. **Wood Pole.** Provide and install, relocate, or remove wood poles and associated hardware for supporting span wire and bracket-arm-mounted traffic signals, and guying the pole per span.

Tamp the earth replaced around new or relocated poles. Fill, tamp, and level holes after removing poles. Use hot dip galvanized turnbuckles, tension tie bars, and associated steel hardware in accordance with ASTM A153/A153M.

Set wood poles to the minimum depths specified in Table 818-1:

Table 818-1:
Wood Pole Lengths and Depths

Pole Length	Depth
35-foot Class 4 pole	6 feet
40-foot Class 4 pole	6 feet
45-foot Class 4 pole	6½ feet
50-foot Class 4 pole	7 feet
55-foot Class 4 pole	7½ feet
60-foot Class 4 pole	8 feet

818.04. MEASUREMENT AND PAYMENT

Unless otherwise required, the unit prices for the pay items listed in this subsection include the cost of excavation, granular material, backfill, and disposal of waste excavated material. Restoring the site in kind in accordance with section 816 will be paid for separately.

A. **Conduit.** The Engineer will measure conduit in place, from the inside walls of manholes, and the centers of handholes, post foundations, and cable poles.

The unit prices for **Conduit, Rem** include the cost of removing the type, number, and size of conduit shown on the plans.

The unit prices for **Conduit, (type), inch** and **Conduit, DB, (number), __ inch** include the cost of installing the type, number, and size of conduit shown on the plans, and installing marking tape.

The unit price for **Conduit, (type), inch, Structure** includes the cost of providing and installing the conduit components, hardware, and other appurtenances required.

The unit price for **Conduit, Jacked Bored, (number), inch** includes the cost of installing rigid metal, or Schedule 80 PVC conduit.

The unit price for **Conduit, Directional Bore, (number), inch** includes the cost of installing Schedule 80 PE conduit.

The unit price for **Conduit, Encased, (number), inch** includes the cost of the following:

1. Installing conduits;
2. Installing sheeting and bracing;
3. Removing boring pits; and
4. Filling voids.

The unit price for **Conduit, Schedule (number), inch** includes the cost of installing conduit approved for direct burial applications, as specified in subsection 818.02.A.1, and installing marking tape.

B. **Direct Burial Cable.** Not Used.

C. **Cable, Removal.** The unit prices for **Cable, Rem** and **Cable, (type), Rem** include the cost of dead ending, circuit cutting, work required to leave circuits operable, and disposing of the removed cables, wire, hardware, and other appurtenances.

The unit prices for other items of work include the cost of abandoning cables and conduit.

D. **Cable, Pole Dismantle.** Not Used.

E. **Cable, P.J.; Cable, Section; Cable, Shielded, and Cable, Street Lighting.** Not Used.

F. **Cable, Equipment Grounding Wire.** Not Used.

G. **Electrical Service, Removal.** Not Used.

H. **Handholes (Hh).** Not Used.

I. **Service Disconnect.** Not Used.

J. **Metered Service.** Not Used.

K. **Unmetered Service.** Not Used.

L. **Wood Pole.** Not Used.

M. **Concrete Pole, Fit Up.** Not Used.

N. **Steel Pole, Fit Up.** Not Used.

O. Bracket Arm. Not Used.

818.05 BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
MDOT-818.05.01	Airfield Light Can Bases, Rem	Each (EA)
MDOT-818.05.02	Cable/Conduit, Rem	Linear Foot (LF)
MDOT-818.05.03	Place Salvaged Security Camera and Pole (Including New Foundation)	Each (EA)
MDOT-818.05.04	THWN Cables	Linear Foot (LF)
MDOT-818.05.05	COMM Cables	Linear Foot (LF)
MDOT-818.05.06	Remove, Salvage, & Install Security Camera on Hangar	Each (EA)
MDOT-818.05.07	Airfield Light Can Bases, Rem	Each (EA)
MDOT-818.05.08	Cable/Conduit, Rem	Linear Foot (LF)
MDOT-818.05.09	Place Salvaged Security Camera and Pole (Including New Foundation)	Each (EA)
MDOT-818.05.10	THWN Cables	Linear Foot (LF)
MDOT-818.05.11	COMM Cables	Linear Foot (LF)

END OF ITEM MDOT-818

Item CDET-003 Excavation, Backfilling, Grading and Removals

3.I.1 WORK INCLUDED

The work under this Division shall consist of the following items:

A. Excavation. Not Used

B. Basement Cleanout. Not Used

C. Berm Grading. Not Used

D. Fill, Grade A

E. Subbase Material (22.A). Not Used

F. Cold Patching. Not Used

G. Stoning and Grading. Not Used

H. Ditching. Not Used

I. Tree and Stump Removal. Not Used

J. Street Pavement Removal. Not Used

K. Alley Pavement Removal. Not Used

L. Separate Type Curb Removal-Unreinforced and Reinforced. Not Used

M. Integral Type Curb Removal. Not Used

N. Partial Curb Removal. Not Used

O. Curb and Gutter Removal-Unreinforced and Reinforced. Not Used

P. Concrete Walk Removal. Not Used

Q. Concrete Drive Removal. Not Used

R. Streetcar Track Base Removal. Not Used

S. Streetcar Rail Removal. Not Used

T. Spur Track Removal. Not Used

U. Concrete Slab Removal. Not Used

V. Reinforced Concrete Slab Removal. Not Used

W. Reinforced Concrete Removal. Not Used

X. Non-Reinforced Concrete Removal. Not Used

Y. Miscellaneous Reinforced Concrete Removal. Not Used

Z. Removing Underground Storage Tank. Not Used

AA. Litter Removal. Not Used

3.I.2 REFERENCED PUBLICATIONS

Michigan Department of Transportation (M.D.O.T.) Standard Specifications for Construction

3.II.1 MATERIAL OF EXCAVATION Not Used

3.II.2 FILL MATERIALS

A. Selected Excavated Materials: Earth materials excavated under this contract to be suitable for backfill behind the curb and pavement in low areas and basements in the berm area. shall be a type which can be compacted to the density specified. Such material to be usable, shall be free from rubbish or debris, vegetable matter, frozen lumps, boulders, large stones, concrete fragments, or other road material, lumber, tree roots. or branches. Selected excavated material considered suitable for backfill shall be sand, sand-gravel, crumbly yellow clay or a combination thereof.

   Blue clay shall not be considered suitable backfill material.

B. Granular Materials for Fill and Subbase: Not Used

C. Approach Aggregates: Not Used

D. Cold Patch Mixture: Not Used

E. Crushed Concrete: Not Used

3.III.1 EXCAVATION AND GRADING Not Used

3.III.2 BERM EXCAVATION AND GRADING Not Used

3.III.3 BACKFILL

A. Each layer of material shall be compacted to not less than 95 percent of the Maximum Unit Weight.

   In the event that the specified percentage of maximum unit weight and the specified moisture content have been attained but the compacted material is not sufficiently stable to provide proper support for the subbase, the Engineer may direct that the material be dried by aeration and recompacted. The aeration shall be accomplished by disking or manipulation by other approved means.

   When directed by the Engineer. the Contractor shall dig test holes required for testing compaction of backfill or fill.

B. Subbase: Not Used

C. Backfill Behind Curb and Pavement, and in Basements: Excavated materials suitable for backfilling behind the curb and pavement, and in basements outside the subgrade area as shown on the Plans shall be deposited and spread in not more than 230-mm (9-inch) layers, loose measure, or as directed by the Engineer. Compaction shall be by pneumatic or vibratory type compactors, hand tamps, or other approved methods.

   Compaction shall be by the Controlled Density Method to at least 95 percent of the Maximum Unit Weight, as described in Sub-Article 3.III.3A.

Where the excavated material is in insufficient quantities or does not meet the specified requirements, suitable fill shall be furnished at no additional cost to the City.

Excavated material used for filling behind curb and pavement, and in basements will not be paid for as a separate item but will be considered incidental to and part of the pay item “Excavation”.

D. Basis of Payment: Subbase material (22A) and Fill (Grade A) will be paid for in cubic yards of volume of material measured, compacted in place at the Contract Unit Price for "Fill (22A)", and "Fill (Grade A)", respectively.

Quantities will be determined on the basis of design sections as shown on the Plans or where changes are made by the Engineer, on the basis of measurements taken before and after filling.

E. Backfilling Abandoned Streets and Alleys: Not Used

3.III.4 DISPOSAL OF EXCAVATED MATERIAL Not Used

3.IV WORKMANSHIP-REMOVALS Not Used

BASIS OF PAYMENT

A. **General.** All unit prices shall constitute full compensation for furnishing material and equipment, set up, maintenance thereof, cleanup, and all other labor, materials, equipment, tools and incidentals necessary to accomplish each item.

Payment will be made under:

ITEM NO.	DESCRIPTION	UNIT OF MEASUREMENT
CDET-003.01.01	Clean Backfill Material	Cubic Yard (CY)

END OF ITEM CDET-003