Naval Facilities Engineering Command
FEC SOUTHEAST

WORK ORDER NO. 0035

CONTRACT NO. N69450-11-D-0073

Volume 3
Repair Runway Pavement and Lighting

At the

Forrest Sherman Field
NAS Pensacola, FL

Final Submittal

PREPARED BY:

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N69450-11-D-0073

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Specifications:

For Commander, NAVFAC:
Date:

PROJECT TABLE OF CONTENTS

DIVISION 02 - EXISTING CONDITIONS

02 41 00 DEMOLITION AND DECONSTRUCTION

DIVISION 03 - CONCRETE

03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE

DIVISION 26 - ELECTRICAL

26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS
26 05 48.00 10 SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT
26 12 21 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS
26 20 00 INTERIOR DISTRIBUTION SYSTEM
26 41 00 LIGHTNING PROTECTION SYSTEM
26 56 20.00 10 AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS

DIVISION 27 - COMMUNICATIONS

27 13 23.00 40 COMMUNICATIONS OPTICAL BACKBONE CABLING

DIVISION 31 - EARTHWORK

31 05 19 GEOTEXTILE

DIVISION 33 - UTILITIES

33 05 23.13 UTILITY HORIZONTAL DIRECTIONAL DRILLING
33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION

-- End of Project Table of Contents --

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
REPAIR RUNWAY PAVEMENT AND LIGHTING

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION	GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
							SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	ACTION CODE	DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION	MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
(a)	(b)	(c)	(d)	(e)	(f)		(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		02 41 00	SD-01 Preconstruction Submittals															
			Demolition Plan	1.2.1	G													
			Deconstruction Plan	1.2.1	G													
			Existing Conditions	1.10														
			SD-07 Certificates															
			Notification	1.6	G													
		03 30 53	SD-02 Shop Drawings															
			Installation Drawings	1.4	G													
			SD-03 Product Data															
			Air-Entraining Admixture	2.2.3.1														
			Water-Reducing or Retarding	2.2.3.2														
			Admixture															
			Curing Materials	2.2.10														
			Expansion Joint Filler Strips,	2.2.6														
			Premolded															
			Joint Sealants - Field Molded	2.2.7														
			Sealants															
			Conveying and Placing Concrete	3.2														
			Formwork	2.2.8														
			Mix Design Data	2.3	G													
			Ready-Mix Concrete	2.3														
			Curing Compound	2.4.1														
			SD-06 Test Reports															
			Aggregates	2.2.2														
			Concrete Mixture Proportions	2.1.3	G													
			Compressive Strength Testing	3.8.3	G													

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
REPAIR RUNWAY PAVEMENT AND LIGHTING

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION	GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
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		03 30 53	Slump	3.8.3	G													
			Water	2.2.4														
			SD-07 Certificates															
			Cementitious Materials	2.2.1														
			Aggregates	2.2.2														
			Delivery Tickets	2.3														
			SD-08 Manufacturer’s Instructions															
			Curing Compound	2.4.1														
		26 05 48.00 10	SD-02 Shop Drawings															
			Equipment Requirements	1.3														
			SD-03 Product Data															
			Equipment Requirements	1.3	G													
			Contractor Designed Bracing	1.2.4	G													
		26 12 21	SD-02 Shop Drawings															
			Pad-mounted transformer	1.4.1	G													
			drawings															
			SD-03 Product Data															
			Single-phase pad-mounted	2.2	G													
			transformers (dead-front)															
			SD-06 Test Reports															
			Acceptance checks and tests	3.6.1	G													
			SD-07 Certificates															
			Transformer efficiencies	2.2.2.1	G													
			SD-09 Manufacturer’s Field															
			Reports															
			design tests	2.9.1	G													

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
REPAIR RUNWAY PAVEMENT AND LIGHTING

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION	GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
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(a)	(b)	(c)	(d)	(e)	(f)		(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		26 12 21	routine and other tests	2.9.2	G													
			SD-10 Operation and Maintenance															
			Data															
			Transformer	1.5.1	G													
		26 20 00	SD-02 Shop Drawings															
			Panelboards	2.7	G													
			Transformers	2.9	G													
			Wireways	2.14	G													
			SD-03 Product Data															
			Circuit breakers	2.7.3	G													
			Switches	2.6	G													
			Transformers	2.9	G													
			Enclosed circuit breakers	2.8	G													
			Surge protective devices	2.15	G													
			SD-06 Test Reports															
			600-volt wiring test	3.5.2	G													
			Grounding system test	3.5.4	G													
			Transformer tests	3.5.3	G													
			SD-09 Manufacturer’s Field															
			Reports															
			Transformer factory tests	2.17.1														
		26 41 00	SD-02 Shop Drawings															
			Each major component	1.4.1.1	G													
			SD-06 Test Reports															
			Lightning Protection and	1.4.3	G													
			Grounding System Test Plan															

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
REPAIR RUNWAY PAVEMENT AND LIGHTING

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION	GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
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		26 41 00	Lightning Protection and	3.4.1	G													
			Grounding System Test															
			SD-07 Certificates															
			Lightning Protection System	1.2.3	G													
			Installers Documentation															
			Component UL Listed and	1.4.2	G													
			Labeled															
		26 56 20.00 10	SD-02 Shop Drawings															
			Lighting and Visual Navigation	2.1	G													
			Aids															
			As-Built Drawings	1.3.5														
			SD-03 Product Data															
			Materials and Equipment	2.2														
			Protection Plan	1.3.3														
			Training	3.19														
			Special Tools	3.19														
			List of Parts	3.19														
			Maintenance and Repair	3.19														
			Posted Instructions	3.21														
			SD-06 Test Reports															
			Field Quality Control	3.18														
			Visual Inspection	3.18.3														
			SD-07 Certificates															
			Qualifications	1.3.2														
			Materials and Equipment	2.2														

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
REPAIR RUNWAY PAVEMENT AND LIGHTING

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION	GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
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		26 56 20.00 10	SD-10 Operation and Maintenance															
			Data															
			Operation and Maintenance	3.19	G													
			Procedures															
		27 13 23.00 40	SD-01 Preconstruction Submittals															
			Qualifications	1.3.1	G													
			Quality Assurance Plan	1.3.1	G													
			SD-02 Shop Drawings															
			Fiber Optic System Contract	1.3.1	G													
			Drawings															
			Detailed Shop Drawings	1.3.1	G													
			Record (As-Built) Drawings	3.3	G													
			SD-03 Product Data															
			Optical Fibers	1.3.1	G													
			Fiber Optic Cable Design	1.3.1	G													
			Fiber Optic Terminal Cabinets	1.3.1	G													
			Fiber Optic Terminal Cabinets	2.2.2	G													
			Fiber Optic Media Types	1.3.1	G													
			Fiber Optic Terminations and	1.3.1	G													
			Connectors															
			Fiber Optic Enclosures	1.3.1	G													
			SD-06 Test Reports															
			Factory Test Certificates	2.4.2	G													
			Single and Multi-Mode OTDR	3.2.1.1	G													
			Test															
			End-to-End Attenuation Tests	3.2.1.2	G													

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
REPAIR RUNWAY PAVEMENT AND LIGHTING

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION	GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
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		27 13 23.00 40	End-to-End Bandwidth Tests	3.2.1.3	G													
			Fiber Optic Factory Test Plan	1.5.4	G													
			Fiber Optic Field Tests Plan	1.5.5	G													
			SD-07 Certificates															
			Fiber Optic Cable Installer and	1.3.1	G													
			Splicer Qualifications															
			Manufacturer's Qualifications	1.3.1	G													
			SD-08 Manufacturer’s Instructions															
			Fiber Optic System Instructions	1.3.1	G													
		31 05 19	SD-03 Product Data															
			Manufacturing Quality Control	2.2														
			Sampling and Testing															
			SD-04 Samples															
			Quality Assurance Samples and	3.1														
			Tests															
			SD-07 Certificates															
			Geotextile	2.1.1														
		33 05 23.13	SD-01 Preconstruction Submittals															
			Statement of Qualifications and	1.3	G													
			Records															
			SD-02 Shop Drawings															
			Record Drawings	3.3	G													
			SD-03 Product Data															
			Fused High Density Polyethylene	1.3	G													
			Pipe or Fused PVC Carrier Pipe															
			Drilling Fluids	1.3	G													

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
REPAIR RUNWAY PAVEMENT AND LIGHTING

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION	GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					
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		33 05 23.13	Additives	1.3	G													
			Mixtures	1.3	G													
			Hdpe Inner Conduits	1.3														
			Spacers For Inner Conduits	1.3														
			Flexible Fill (Controlled Low	1.3														
			Strength Material) Concrete Mix															
			SD-05 Design Data															
			Material Safety Data Sheets	1.3	G													
			SD-06 Test Reports															
			Soil Test Data	1.3	G													
			SD-07 Certificates															
			Drill Rod	2.1.1	G													
			SD-11 Closeout Submittals															
			Complete Work Logs of Guided	3.3	G													
			Directional Drill Operations															
		33 71 02	SD-03 Product Data															
			Medium voltage cable	2.5	G													
			Medium voltage cable joints	2.7	G													
			Medium voltage cable	2.6	G													
			terminations															
			SD-06 Test Reports															
			Medium voltage cable	2.12.2	G													
			qualification and production tests															
			Field Acceptance Checks and	3.15.1	G													
			Tests															
			Arc-proofing test	2.12.1	G													

SUBMITTAL REGISTER

CONTRACT NO.

TITLE AND LOCATION
REPAIR RUNWAY PAVEMENT AND LIGHTING

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION	GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY				MAILED TO CONTR/	REMARKS
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(a)	(b)	(c)	(d)	(e)	(f)		(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
		33 71 02	Cable Installation Plan and	3.3	G													
			Procedure															
			SD-07 Certificates															
			Cable splicer/terminator	1.4.1	G													
			Cable Installer Qualifications	1.4.2	G													
			Certificate of Conformance	1.4.3	G													

SECTION TABLE OF CONTENTS

DIVISION 02 - EXISTING CONDITIONS

SECTION 02 41 00

DEMOLITION AND DECONSTRUCTION

05/10

PART 1 GENERAL

1.1 REFERENCES
1.2 PROJECT DESCRIPTION
1.2.1 Demolition/Deconstruction Plan
1.2.2 General Requirements
1.3 ITEMS TO REMAIN IN PLACE
1.3.1 Existing Construction Limits and Protection
1.3.2 Utility Service
1.3.3 Facilities
1.4 BURNING
1.5 SUBMITTALS
1.6 QUALITY ASSURANCE
1.6.1 Dust and Debris Control
1.7 PROTECTION
1.7.1 Traffic Control Signs
1.7.2 Protection of Personnel
1.8 FOREIGN OBJECT DAMAGE (FOD)
1.9 RELOCATIONS
1.10 EXISTING CONDITIONS

PART 2 PRODUCTS

2.1 FILL MATERIAL

PART 3 EXECUTION

3.1 EXISTING FACILITIES TO BE REMOVED
3.1.1 Utilities and Related Equipment
3.1.1.1 General Requirements
3.1.1.2 Disconnecting Existing Utilities
3.1.2 Paving and Slabs
3.1.3 Masonry
3.1.4 Concrete
3.1.5 Airfield Lighting
3.1.6 Patching
3.2 CONCURRENT EARTH-MOVING OPERATIONS
3.3 DISPOSITION OF MATERIAL
3.3.1 Title to Materials
3.3.2 Reuse of Materials and Equipment
3.3.3 Salvaged Materials and Equipment
3.4 CLEANUP
3.5 DISPOSAL OF REMOVED MATERIALS
3.5.1 Regulation of Removed Materials
3.5.2 Removal from Government Property
3.6 REUSE OF SALVAGED ITEMS

-- End of Section Table of Contents --

SECTION 02 41 00

DEMOLITION AND DECONSTRUCTION
05/10

PART 1 GENERAL

1.1 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 ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 145	(1991; R 2012) Standard Specification for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
AASHTO T 180	(2015) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

AMERICAN SOCIETY OF SAFETY ENGINEERS (ASSE/SAFE)

ASSE/SAFE A10.6	(2006) Safety Requirements for Demolition Operations

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety and Health Requirements Manual

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

FAA AC 70/7460-1	(2007; Rev K) Obstruction Marking and Lighting

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 61	National Emission Standards for Hazardous Air Pollutants

1.2 PROJECT DESCRIPTION

1.2.1 Demolition/Deconstruction Plan

Prepare a Demolition Plan and Deconstruction Plan and submit proposed salvage, demolition, deconstruction, and removal procedures for approval before work is started. Include in the plan procedures for careful removal and disposition of materials specified to be salvaged, coordination with other work in progress, a disconnection schedule of utility services, and airfield lighting, a detailed description of methods and equipment to be used for each operation and of the sequence of operations. Identify

components and materials to be salvaged for reuse or recycling with reference to paragraph Existing Facilities to be Removed. Append tracking forms for all removed materials indicating type, quantities, condition, destination, and end use. Coordinate with Waste Management Plan.

1.2.2 General Requirements

Do not begin demolition or deconstruction until authorization is received from the Contracting Officer. The work of this section is to be performed in a manner that maximizes the value derived from the salvage and recycling of materials. Remove rubbish and debris from the station daily; do not allow accumulations on airfield pavements. The work includes demolition, deconstruction, salvage of identified items and materials, and removal of resulting rubbish and debris. Remove rubbish and debris from Government property daily, unless otherwise directed. Store materials that cannot be removed daily in areas specified by the Contracting Officer. In the interest of occupational safety and health, perform the work in accordance with EM 385-1-1, Section 23, Demolition, and other applicable Sections.

1.3 ITEMS TO REMAIN IN PLACE

Take necessary precautions to avoid damage to existing items to remain in place, to be reused, or to remain the property of the Government. Repair or replace damaged items as approved by the Contracting Officer. Coordinate the work of this section with all other work indicated. Construct and maintain shoring, bracing, and supports as required. Ensure that structural elements are not overloaded. Increase structural supports or add new supports as may be required as a result of any cutting, removal, deconstruction, or demolition work performed under this contract. Do not overload structural elements. Provide new supports and reinforcement for existing construction weakened by demolition, deconstruction, or removal work. Repairs, reinforcement, or structural replacement require approval by the Contracting Officer prior to performing such work.

1.3.1 Existing Construction Limits and Protection

Do not disturb existing construction beyond the extent indicated or necessary for installation of new construction. Provide protective measures to control accumulation and migration of dust and dirt in all work areas. Remove dust, dirt, and debris from work areas daily.

1.3.2 Utility Service

Maintain existing utilities indicated to stay in service and protect against damage during demolition and deconstruction operations. Prior to start of work, disconnected and sealed by the Contractor.

1.3.3 Facilities

Protect electrical and mechanical services and utilities. Where removal of existing utilities and pavement is specified or indicated, provide approved barricades, temporary covering of exposed areas, and temporary services or connections for electrical and mechanical utilities.

1.4 BURNING

The use of burning at the project site for the disposal of refuse and debris will not be permitted.

1.5 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Demolition Plan; G
Deconstruction Plan; G
Existing Conditions

SD-07 Certificates

Notification; G

1.6 QUALITY ASSURANCE

Submit timely notification of demolition, deconstruction, and renovation projects to Federal, State, regional, and local authorities in accordance with 40 CFR 61, Subpart M. Notify the Contracting Officer in writing 10 working days prior to the commencement of work in accordance with 40 CFR 61, Subpart M. Comply with federal, state, and local hauling and disposal regulations. In addition to the requirements of the "Contract Clauses," conform to the safety requirements contained in ASSE/SAFE A10.6. Comply with the Environmental Protection Agency requirements specified. Use of explosives will not be permitted.

1.6.1 Dust and Debris Control

Prevent the spread of dust and debris on airfield pavements and avoid the creation of a nuisance or hazard in the surrounding area. Do not use water if it results in hazardous or objectionable conditions such as, but not limited to, flooding, or pollution. Vacuum and dust the work area daily. Sweep pavements as often as necessary to control the spread of debris that may result in foreign object damage potential to aircraft.

1.7 PROTECTION

1.7.1 Traffic Control Signs

a. Where pedestrian and driver or aircraft safety is endangered in the area of removal work, use traffic barricades with flashing lights. Anchor barricades in a manner to prevent displacement by wind, jet or prop blast. Notify the Contracting Officer prior to beginning such work.

Provide a minimum of 2 FAA type L-810 steady burning red obstruction lights on temporary structures (including cranes) over 100 feet, but less than 100 ft, above ground level. The use of LED based obstruction lights are not permitted. For temporary structures (including cranes) over 200 ft above ground level provide obstruction lighting in accordance with FAA AC 70/7460-1. Light construction and installation shall comply with FAA AC 70/7460-1. Lights shall be operational during periods of reduced visibility, darkness, and as directed by the Contracting Officer. Maintain the temporary services during the period of construction and remove only after permanent services have been installed and tested and are in operation.

1.7.2 Protection of Personnel

Before, during and after the demolition and deconstruction work continuously evaluate the condition of the item or structure being demolished and deconstructed and take immediate action to protect all personnel working in and around the project site.

1.8 FOREIGN OBJECT DAMAGE (FOD)

Aircraft and aircraft engines are subject to FOD from debris and waste material lying on airfield pavements. Remove all such materials that may appear on operational aircraft pavements due to the Contractor's operations. If necessary, the Contracting Officer may require the Contractor to install a temporary barricade at the Contractor's expense to control the spread of FOD potential debris. The barricade shall include a fence covered with a fabric designed to stop the spread of debris. Anchor the fence and fabric to prevent displacement by winds or jet/prop blasts. Remove barricade when no longer required.

1.9 RELOCATIONS

Perform the removal and reinstallation of relocated items as indicated with workmen skilled in the trades involved. Repair or replace items to be relocated which are damaged by the Contractor with new undamaged items as approved by the Contracting Officer.

1.10 EXISTING CONDITIONS

Before beginning any demolition or deconstruction work, survey the site and examine the drawings and specifications to determine the extent of the work. Record existing conditions in the presence of the Contracting Officer showing the condition of structures and other facilities adjacent to areas of alteration or removal. Photographs sized 4 inch will be acceptable as a record of existing conditions. Include in the record the elevation of the top of foundation walls, finish floor elevations, possible conflicting electrical conduits, plumbing lines, alarms systems, the location and extent of existing cracks and other damage and description of surface conditions that exist prior to before starting work. It is the Contractor's responsibility to verify and document all required outages which will be required during the course of work, and to note these outages on the record document. Submit survey results.

PART 2 PRODUCTS

2.1 FILL MATERIAL

a. Comply with excavating, backfilling, and compacting procedures for soils used as backfill material to fill basements, voids, depressions or excavations resulting from demolition or deconstruction of structures. Fill material shall be waste products from demolition or deconstruction until all waste appropriate for this purpose is consumed.

b. Fill material shall conform to the definition of satisfactory soil material as defined in AASHTO M 145, Soil Classification Groups A-1, A-2-4, A-2-5 and A-3. In addition, fill material shall be free from roots and other organic matter, trash, debris, frozen materials, and stones larger than 2 inches in any dimension.

c. Proposed fill material must be sampled and tested by an approved soil

testing laboratory, as follows:

Soil classification	AASHTO M 145
Moisture-density relations	AASHTO T 180, Method B or D

PART 3 EXECUTION

3.1 EXISTING FACILITIES TO BE REMOVED

3.1.1 Utilities and Related Equipment

3.1.1.1 General Requirements

Do not interrupt existing utilities serving occupied or used facilities, except when authorized in writing by the Contracting Officer. Do not interrupt existing utilities serving facilities occupied and used by the Government except when approved in writing and then only after temporary utility services have been approved and provided. Do not begin demolition or deconstruction work until all utility disconnections have been made. Shut off and cap utilities for future use, as indicated.

3.1.1.2 Disconnecting Existing Utilities

Remove existing utilities, as indicated or uncovered by work and terminate in a manner conforming to the nationally recognized code covering the specific utility and approved by the Contracting Officer. When utility lines are encountered but are not indicated on the drawings, notify the Contracting Officer prior to further work in that area.

3.1.2 Paving and Slabs

Remove sawcut concrete and asphaltic concrete paving and slabs including aggregate base as indicated. Provide neat sawcuts at limits of pavement removal as indicated. Pavement and slabs not to be used in this project shall be removed from the Installation at Contractor's expense.

3.1.3 Masonry

Sawcut and remove masonry so as to prevent damage to surfaces to remain, and to facilitate the installation of new work. Where new masonry adjoins existing, the new work shall abut or tie into the existing construction as indicated. Provide square, straight edges and corners where existing masonry adjoins new work and other locations.

3.1.4 Concrete

Saw concrete along straight lines to a depth of a minimum 2 inch. Make each cut in walls perpendicular to the face and in alignment with the cut in the opposite face. Break out the remainder of the concrete provided that the broken area is concealed in the finished work, and the remaining concrete is sound. At locations where the broken face cannot be concealed, grind smooth or saw cut entirely through the concrete.

3.1.5 Airfield Lighting

Remove existing airfield lighting as indicated and terminate in a manner satisfactory to the Contracting Officer. Remove edge lights and associated transformers as indicated and deliver to a location on the station in

accordance with instructions of the Contracting Officer or dispose of off station as indicated.

3.1.6 Patching

Where removals leave holes and damaged surfaces exposed in the finished work, patch and repair these holes and damaged surfaces to match adjacent finished surfaces, using on-site materials when available. Where new work is to be applied to existing surfaces, perform removals and patching in a manner to produce surfaces suitable for receiving new work. Finished surfaces of patched area shall be flush with the adjacent existing surface and shall match the existing adjacent surface as closely as possible as to texture and finish. Patching shall be as specified and indicated, and shall include:

a. Concrete and Masonry: Completely fill holes and depressions, caused by previous physical damage or left as a result of removals in existing masonry walls to remain, with an approved masonry patching material, applied in accordance with the manufacturer's printed instructions.

3.2 CONCURRENT EARTH-MOVING OPERATIONS

Do not begin excavation, filling, and other earth-moving operations that are sequential to demolition or deconstruction work in areas occupied by structures to be demolished or deconstructed until all demolition and deconstruction in the area has been completed and debris removed. Fill holes, open basements and other hazardous openings.

3.3 DISPOSITION OF MATERIAL

3.3.1 Title to Materials

Except for salvaged items specified in related Sections, and for materials or equipment scheduled for salvage, all materials and equipment removed and not reused or salvaged, shall become the property of the Contractor and shall be removed from Government property. Title to materials resulting from demolition and deconstruction, and materials and equipment to be removed, is vested in the Contractor upon approval by the Contracting Officer of the Contractor's demolition, deconstruction, and removal procedures, and authorization by the Contracting Officer to begin demolition and deconstruction. The Government will not be responsible for the condition or loss of, or damage to, such property after contract award. Showing for sale or selling materials and equipment on site is prohibited.

3.3.2 Reuse of Materials and Equipment

Remove and store materials and equipment listed to be reused or relocated to prevent damage, and reinstall as the work progresses.

3.3.3 Salvaged Materials and Equipment

Remove materials and equipment that are listed as directed and specified to be removed by the Contractor and that are to remain the property of the Government, and deliver to a storage site on the airfield.

a. Salvage items and material to the maximum extent possible.

b. Store all materials salvaged for the Contractor as approved by the

Contracting Officer and remove from Government property before completion of the contract. On site sales of salvaged material is prohibited.

c. Remove salvaged items to remain the property of the Government in a manner to prevent damage, and packed or crated to protect the items from damage while in storage or during shipment. Items damaged during removal or storage must be repaired or replaced to match existing items. Salvaged items include LED airfield lights, constant current regulator, and sump pumps.

3.4 CLEANUP

Remove debris and rubbish from basement and similar excavations. Remove and transport the debris in a manner that prevents spillage on streets or adjacent areas. Apply local regulations regarding hauling and disposal.

3.5 DISPOSAL OF REMOVED MATERIALS

3.5.1 Regulation of Removed Materials

Dispose of debris, rubbish, scrap, and other nonsalvageable materials resulting from removal operations with all applicable federal, state and local regulations as contractually specified.

3.5.2 Removal from Government Property

Transport waste materials removed from demolished and deconstructed structures, except waste soil, from Government property for legal disposal. Dispose of waste soil as directed.

3.6 REUSE OF SALVAGED ITEMS

Recondition salvaged materials and equipment designated for reuse before installation. Replace items damaged during removal and salvage operations or restore them as necessary to usable condition.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 03 - CONCRETE

SECTION 03 30 53

MISCELLANEOUS CAST-IN-PLACE CONCRETE

05/14

PART 1 GENERAL

1.1 SUMMARY
1.2 REFERENCES
1.3 SUBMITTALS
1.4 QUALITY ASSURANCE

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION
2.1.1 Strength
2.1.2 Construction Tolerances
2.1.3 Concrete Mixture Proportions
2.2 MATERIALS
2.2.1 Cementitious Materials
2.2.1.1 Portland Cement
2.2.1.2 Pozzolan
2.2.2 Aggregates
2.2.3 Admixtures
2.2.3.1 Air-Entraining Admixture
2.2.3.2 Water-Reducing or Retarding Admixture
2.2.4 Water
2.2.5 Reinforcing Steel
2.2.6 Expansion Joint Filler Strips, Premolded
2.2.7 Joint Sealants - Field Molded Sealants
2.2.8 Formwork
2.2.9 Form Coatings
2.2.10 Curing Materials
2.3 READY-MIX CONCRETE
2.4 ACCESSORIES
2.4.1 Curing Compound

PART 3 EXECUTION

3.1 PREPARATION
3.1.1 Embedded Items
3.1.2 Formwork Installation
3.1.3 Production of Concrete
3.1.3.1 Ready-Mixed Concrete
3.1.3.2 Concrete Made by Volumetric Batching and Continuous Mixing
3.2 CONVEYING AND PLACING CONCRETE
3.2.1 Cold-Weather Requirements
3.2.2 Hot-Weather Requirements
3.3 FINISHING
3.3.1 Temperature Requirement
3.3.2 Finishing Formed Surfaces

3.3.3 Finishing Unformed Surfaces
3.3.3.1 Expansion and Contraction Joints
3.4 CURING AND PROTECTION
3.5 FORM WORK
3.5.1 Removal of Forms
3.6 STEEL REINFORCING
3.6.1 Fabrication
3.6.2 Supports
3.7 EMBEDDED ITEMS
3.8 TESTING AND INSPECTING
3.8.1 Field Testing Technicians
3.8.2 Preparations for Placing
3.8.3 Sampling and Testing
3.8.4 Action Required
3.8.4.1 Placing
3.8.4.2 Air Content
3.8.4.3 Slump

-- End of Section Table of Contents --

SECTION 03 30 53

MISCELLANEOUS CAST-IN-PLACE CONCRETE
05/14

PART 1 GENERAL

1.1 SUMMARY

Perform all work in accordance with ACI 318.

1.2 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 CONCRETE INSTITUTE INTERNATIONAL (ACI)

ACI 117	(2010; Errata 2011) Specifications for Tolerances for Concrete Construction and Materials and Commentary
ACI 301	(2010; ERTA 2015) Specifications for Structural Concrete
ACI 304R	(2000; R 2009) Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305R	(2010) Guide to Hot Weather Concreting
ACI 306R	(2010) Guide to Cold Weather Concreting
ACI 318	(2014; Errata 1-2 2014; Errata 3-4 2015) Building Code Requirements for Structural Concrete and Commentary
ACI 347	(2004; Errata 2008; Errata 2012) Guide to Formwork for Concrete
ACI SP-66	(2004) ACI Detailing Manual

ASTM INTERNATIONAL (ASTM)

ASTM A1064/A1064M	(2015) Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A615/A615M	(2015a) Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM C1064/C1064M	(2011) Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete

ASTM C143/C143M	(2012) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150/C150M	(2015) Standard Specification for Portland Cement
ASTM C1602/C1602M	(2012) Standard Specification for Mixing Water Used in Production of Hydraulic Cement Concrete
ASTM C172/C172M	(2014a) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C231/C231M	(2014) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260/C260M	(2010a) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	(2011) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C31/C31M	(2012) Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33/C33M	(2013) Standard Specification for Concrete Aggregates
ASTM C39/C39M	(2015a) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C494/C494M	(2013) Standard Specification for Chemical Admixtures for Concrete
ASTM C618	(2012a) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C685/C685M	(2014) Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM C94/C94M	(2015) Standard Specification for Ready-Mixed Concrete
ASTM D1752	(2004a; R 2013) Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
ASTM D75/D75M	(2014) Standard Practice for Sampling Aggregates

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Installation Drawings; G

SD-03 Product Data

Air-Entraining Admixture
Water-Reducing or Retarding Admixture
Curing Materials
Expansion Joint Filler Strips, Premolded
Joint Sealants - Field Molded Sealants
Conveying and Placing Concrete
Formwork
Mix Design Data; G
Ready-Mix Concrete
Curing Compound

SD-06 Test Reports

Aggregates
Concrete Mixture Proportions; G
Compressive Strength Testing; G
Slump; G
Water

SD-07 Certificates

Cementitious Materials
Aggregates
Delivery Tickets

SD-08 Manufacturer's Instructions

Curing Compound

1.4 QUALITY ASSURANCE

Indicate specific locations of Concrete Placement, Forms, Steel Reinforcement, Accessories, and Construction Joints on installation drawings and include, but not be limited to, square feet of concrete placements, thicknesses and widths, plan dimensions, and arrangement of cast-in-place concrete section.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

The Government retains the option to sample and test joint filler material aggregates and concrete to determine compliance with the specifications. Provide facilities and labor as may be necessary to assist the Government in procurement of representative test samples. Obtain samples of aggregates at the point of batching in accordance with ASTM D75/D75M.

Sample concrete in accordance with ASTM C172/C172M. Determine slump and air content in accordance with ASTM C143/C143M and ASTM C231/C231M, respectively, when cylinders are molded. Prepare, cure, and transport compression test specimens in accordance with ASTM C31/C31M. Test compression test specimens in accordance with ASTM C39/C39M. Take samples for strength tests not less than once each shift in which concrete is produced. Provide a minimum of five specimens from each sample; two to be tested at 28 days (90 days if pozzolan is used) for acceptance, two will be tested at 7 days for information and one held in reserve.

2.1.1 Strength

Acceptance test results are the average strengths of two specimens tested at 28 days (90 days if pozzolan is used). The strength of the concrete is considered satisfactory so long as the average of three consecutive acceptance test results equal or exceed the specified compressive strength, f'c, but not more than 20 percent, and no individual acceptance test result falls below f'c by more than 500 psi.

2.1.2 Construction Tolerances

Apply a Class "C" finish to all surfaces except those specified to receive a Class "D" finish. Apply a Class "D" finish to all post-construction surfaces which will be permanently concealed. Surface requirements for the classes of finish required are as specified in ACI 117.

2.1.3 Concrete Mixture Proportions

Concrete mixture proportions are the responsibility of the Contractor. Mixture proportions must include the dry weights of cementitious material(s); the nominal maximum size of the coarse aggregate; the specific gravities, absorptions, and saturated surface-dry weights of fine and coarse aggregates; the quantities, types, and names of admixtures; and quantity of water per yard of concrete. Provide materials included in the mixture proportions of the same type and from the same source as will be used on the project. The specified compressive strength f'c is 4,000 psi minimum at 28 days (90 days if pozzolan is used). The maximum nominal size coarse aggregate is 1 inch, in accordance with ACI 304R. The air content must be between 4.5 and 7.5 percent with a slump between 2 and 5 inches. The maximum water-cementitious material ratio is 0.50. Submit the applicable test reports and mixture proportions that will produce concrete of the quality required, ten days prior to placement of concrete.

2.2 MATERIALS

Submit manufacturer's literature from suppliers which demonstrates compliance with applicable specifications for the specified materials.

2.2.1 Cementitious Materials

Submit Manufacturer's certificates of compliance, accompanied by mill test reports, attesting that the concrete materials meet the requirements of the specifications in accordance with the Special Clause "CERTIFICATES OF COMPLIANCE". Provide cementitious materials that conform to the appropriate specifications listed:

2.2.1.1 Portland Cement

ASTM C150/C150M, Type V, with tri-calcium aluminates (C3A) content less

than 10 percent and a maximum cement-alkali content of 0.80 percent Na2Oe (sodium oxide) equivalent.

2.2.1.2 Pozzolan

Provide pozzolan that conforms to ASTM C618, Class F, including requirements of Tables 1A and 2A.

2.2.2 Aggregates

For fine and coarse aggregates meet the quality and grading requirements of ASTM C33/C33M and test and evaluate for alkali-aggregate reactivity in accordance with Section 32 13 11 CONCRETE PAVEMENT FOR AIRFIELDS AND OTHER HEAVY-DUTY PAVEMENTS. Provide aggregates that do not contain any substance which may be delieteriously reactive with the adjension of the cement. Submit certificates of compliance and test reports for aggregates showing the material(s) meets the quality and grading requirements of the specifications under which it is furnished.

2.2.3 Admixtures

Provide admixtures, when required or approved, in compliance with the appropriate specification listed. Retest chemical admixtures that have been in storage at the project site, for longer than 6 months or that have been subjected to freezing, at the expense of the Contractor at the request of the Contracting Officer and will be rejected if test results are not satisfactory.

2.2.3.1 Air-Entraining Admixture

Provide air-entraining admixture that meets the requirements of ASTM C260/C260M.

2.2.3.2 Water-Reducing or Retarding Admixture

Provide water-reducing or retarding admixture meeting the requirements of ASTM C494/C494M, Type A, B, or D.

2.2.4 Water

Mixing and curing water in compliance with the requirements of ASTM C1602/C1602M; free of injurious amounts of oil, acid, salt, or alkali. Submit test report showing water complies with ASTM C1602/C1602M.

2.2.5 Reinforcing Steel

Provide reinforcing bars conforming to the requirements of ASTM A615/A615M, Grade 60, deformed. Provide welded steel wire reinforcement conforming to the requirements of ASTM A1064/A1064M. Detail reinforcement not indicated in accordance with ACI 301 and ACI SP-66.

2.2.6 Expansion Joint Filler Strips, Premolded

Expansion joint filler strips, premolded of sponge rubber conforming to ASTM D1752, Type I.

2.2.7 Joint Sealants - Field Molded Sealants

Conform to ASTM C920, Type M, Grade NS, Class 25, use NT for vertical

joints and Type M, Grade P, Class 25, use T for horizontal joints. Provide polyethylene tape, coated paper, metal foil, or similar type bond breaker materials. The backup material needs to be compressible, nonshrink, nonreactive with the sealant, and a nonabsorptive material such as extruded butyl or polychloroprene foam rubber. Immediately prior to installation of field-molded sealants, clean the joint of all debris and further cleaned using water, chemical solvents, or other means as recommended by the sealant manufacturer or directed.

2.2.8 Formwork

Design and engineer the formwork as well as its construction in accordance with ACI 301 Section 2 and 5 and ACI 347. Fabricate of wood, steel, or other approved material. Submit formwork design prior to the first concrete placement.

2.2.9 Form Coatings

Provide form coating in accordance with ACI 301.

2.2.10 Curing Materials

Provide curing materials in accordance with ACI 301, Section 5.

2.3 READY-MIX CONCRETE

Provide ready-mix concrete with mix design data conforming to ACI 301 Part 2. Submit delivery tickets in accordance with ASTM C94/C94M for each ready-mix concrete delivery, include the following additional information: .

a. Type and brand cement

b. Cement content in 94-pound bags per cubic yard of concrete

c. Maximum size of aggregate

d. Amount and brand name of admixture

e. Total water content expressed by water cementitious material ratio

2.4 ACCESSORIES

2.4.1 Curing Compound

Provide curing compound conforming to ASTM C309. Submit manufactures instructions for placing curing compound.

PART 3 EXECUTION

3.1 PREPARATION

Prepare construction joints to expose coarse aggregate. The surface must be clean, damp, and free of laitance. Construct ramps and walkways, as necessary, to allow safe and expeditious access for concrete and workmen. Remove snow, ice, standing or flowing water, loose particles, debris, and foreign matter. Satisfactorily compact earth foundations. Make spare vibrators available. Placement cannot begin until the entire preparation has been accepted by the Government.

3.1.1 Embedded Items

Secure reinforcement in place after joints, anchors, and other embedded items have been positioned. Arrange internal ties so that when the forms are removed the metal part of the tie is not less than 2 inches from concrete surfaces permanently exposed to view or exposed to water on the finished structures. Prepare embedded items so they are be free of oil and other foreign matters such as loose coatings or rust, paint, and scale. The embedding of wood in concrete is permitted only when specifically authorized or directed. Provide all equipment needed to place, consolidate, protect, and cure the concrete at the placement site and in good operating condition.

3.1.2 Formwork Installation

Forms must be properly aligned, adequately supported, and mortar-tight. Provide smooth form surfaces, free from irregularities, dents, sags, or holes when used for permanently exposed faces. Chamfer all exposed joints and edges , unless otherwise indicated.

3.1.3 Production of Concrete

3.1.3.1 Ready-Mixed Concrete

Provide ready-mixed concrete conforming to ASTM C94/C94M except as otherwise specified.

3.1.3.2 Concrete Made by Volumetric Batching and Continuous Mixing

Conform to ASTM C685/C685M.

3.2 CONVEYING AND PLACING CONCRETE

Convey and place concrete in accordance with ACI 301, Section 5.

3.2.1 Cold-Weather Requirements

Place concrete in cold weather in accordance with ACI 306R

3.2.2 Hot-Weather Requirements

Place concrete in hot weather in accordance with ACI 305R

3.3 FINISHING

3.3.1 Temperature Requirement

Do not finish or repair concrete when either the concrete or the ambient temperature is below 50 degrees F.

3.3.2 Finishing Formed Surfaces

Remove all fins and loose materials , and surface defects including filling of tie holes. Repair all honeycomb areas and other defects. Remove all unsound concrete from areas to be repaired. Ream or chip surface defects greater than 1/2 inch in diameter and holes left by removal of tie rods in all surfaces not to receive additional concrete and fill with dry-pack mortar. Brush-coat the prepared area with an approved epoxy resin or latex bonding compound or with a neat cement grout after dampening and filling

with mortar or concrete. Use a blend of portland cement and white cement in mortar or concrete for repairs to all surfaces permanently exposed to view shall be so that the final color when cured is the same as adjacent concrete.

3.3.3 Finishing Unformed Surfaces

Finish unformed surfaces in accordance with ACI 301, Section 5.

FINISH	LOCATION
Broom or Belt	All Structures

3.3.3.1 Expansion and Contraction Joints

Make expansion and contraction joints in accordance with the details shown or as otherwise specified. Provide 1/2 inch thick transverse expansion joints where new work abuts an existing concrete. Provide expansion joints as indicated. Provide contraction joints at a maximum spacing of 6 linear feet in sidewalks, unless otherwise indicated. Cut contraction joints at a minimum of 1 inch(es) deep with a jointing tool after the surface has been finished.

3.4 CURING AND PROTECTION

Cure and protect in accordance with ACI 301, Section 5.

3.5 FORM WORK

Provide form work in accordance with ACI 301, Section 2 and Section 5.

3.5.1 Removal of Forms

Remove forms in accordance with ACI 301, Section 2.

3.6 STEEL REINFORCING

Reinforcement must be free from loose, flaky rust and scale, and free from oil, grease, or other coating which might destroy or reduce the reinforcement's bond with the concrete.

3.6.1 Fabrication

Shop fabricate steel reinforcement in accordance with ACI 318 and ACI SP-66. Provide shop details and bending in accordance with ACI 318 and ACI SP-66.

3.6.2 Supports

Secure reinforcement in place by the use of metal or concrete supports, spacers, or ties.

3.7 EMBEDDED ITEMS

Before placing concrete, take care to determine that all embedded items are firmly and securely fastened in place. Provide embedded items free of oil and other foreign matter, such as loose coatings of rust, paint and scale. Embedding of wood in concrete is permitted only when specifically authorized or directed.

3.8 TESTING AND INSPECTING

Report the results of all tests and inspections conducted at the project site informally at the end of each shift. Submit written reports weekly. Deliver within three days after the end of each weekly reporting period. See Section 01 45 00.00 10 QUALITY CONTROL.

3.8.1 Field Testing Technicians

The individuals who sample and test concrete must have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I.

3.8.2 Preparations for Placing

Inspect foundation or construction joints, forms, and embedded items in sufficient time prior to each concrete placement to certify that it is ready to receive concrete.

3.8.3 Sampling and Testing

a. Obtain samples and test concrete for quality control during placement. Sample fresh concrete for testing in accordance with ASTM C172/C172M. Make six test cylinders.

b. Test concrete for compressive strength at 7 and 28 days for each design mix and for every 100 cubic yards of concrete. Test two cylinders at 7 days; two cylinders at 28 days; and hold two cylinders in reserve. Conform test specimens to ASTM C31/C31M. Perform compressive strength testing conforming to ASTM C39/C39M.

c. Test slump at the site of discharge for each design mix in accordance with ASTM C143/C143M. Check slump once during each shift that concrete is produced.

d. Determine temperature of concrete at time of placement in accordance with ASTM C1064/C1064M. Check concrete temperature at least once during each shift that concrete is placed.

3.8.4 Action Required

3.8.4.1 Placing

Do not begin placement until the availability of an adequate number of acceptable vibrators, which are in working order and have competent operators, has been verified. Discontinue placing if any lift is inadequately consolidated.

3.8.4.2 Air Content

Whenever an air content test result is outside the specification limits, adjust the dosage of the air-entrainment admixture prior to delivery of concrete to forms.

3.8.4.3 Slump

Whenever a slump test result is outside the specification limits, adjust

the batch weights of water and fine aggregate prior to delivery of concrete to the forms. Make the adjustments so that the water-cementitious material ratio does not exceed that specified in the submitted concrete mixture proportion and the required concrete strength is still met.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 00 00.00 20

BASIC ELECTRICAL MATERIALS AND METHODS

07/06

PART 1 GENERAL

1.1 REFERENCES
1.2 RELATED REQUIREMENTS
1.3 DEFINITIONS
1.4 ELECTRICAL CHARACTERISTICS
1.5 ADDITIONAL SUBMITTALS INFORMATION
1.5.1 Shop Drawings (SD-02)
1.5.2 Product Data (SD-03)
1.6 QUALITY ASSURANCE
1.6.1 Regulatory Requirements
1.6.2 Standard Products
1.6.2.1 Alternative Qualifications
1.6.2.2 Material and Equipment Manufacturing Date
1.7 WARRANTY
1.8 MANUFACTURER'S NAMEPLATE
1.9 FIELD FABRICATED NAMEPLATES
1.10 WARNING SIGNS
1.11 ELECTRICAL REQUIREMENTS
1.12 INSTRUCTION TO GOVERNMENT PERSONNEL

PART 2 PRODUCTS

2.1 FACTORY APPLIED FINISH

PART 3 EXECUTION

3.1 FIELD APPLIED PAINTING
3.2 FIELD FABRICATED NAMEPLATE MOUNTING
3.3 WARNING SIGN MOUNTING

-- End of Section Table of Contents --

SECTION 26 00 00.00 20

BASIC ELECTRICAL MATERIALS AND METHODS
07/06

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM D709	(2013) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2012; Errata 1 2012; INT 1-4 2012; Errata 2 2013; INT 5-7 2013; INT 8-10 2014; INT 11 2015) National Electrical Safety Code
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

1.2 RELATED REQUIREMENTS

This section applies to all sections of Division 26 and 33, ELECTRICAL and UTILITIES, of this project specification unless specified otherwise in the individual sections. This section has been incorporated into, and thus, does not apply to, and is not referenced in the following sections.

Section 26 12 21 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS
Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM
Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION
Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP)

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

b. The technical sections referred to herein are those specification sections that describe products, installation procedures, and equipment operations and that refer to this section for detailed description of submittal types.

c. The technical paragraphs referred to herein are those paragraphs in PART 2 - PRODUCTS and PART 3 - EXECUTION of the technical sections that describe products, systems, installation procedures, equipment, and test methods.

1.4 ELECTRICAL CHARACTERISTICS

Electrical characteristics for this project shall be 4.16 kV primary, three phase, three wire, 60 Hz, and 120/240 volts secondary, single phase, three wire and 480/277 volts secondary, three phase, four wire. Final connections to the power distribution system at the existing manholes shall be made by the Contractor as directed by the Contracting Officer.

1.5 ADDITIONAL SUBMITTALS INFORMATION

Submittals required in other sections that refer to this section must conform to the following additional requirements as applicable.

1.5.1 Shop Drawings (SD-02)

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices.

1.5.2 Product Data (SD-03)

Submittal shall include performance and characteristic curves.

1.6 QUALITY ASSURANCE

1.6.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in the technical section.

1.6.2.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.8 MANUFACTURER'S NAMEPLATE

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.9 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified in the technical sections or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 0.125 inch thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be one by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

1.10 WARNING SIGNS

Provide warning signs for the enclosures of electrical equipment including pad-mounted transformers.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28 or IEEE C57.12.29, such as for

pad-mounted transformers, provide self-adhesive warning signs on the outside of the high voltage compartment door(s). Sign shall be a decal and shall have nominal dimensions of 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background. Decal shall be Panduit No. PPSO710D72 or approved equal.

1.11 ELECTRICAL REQUIREMENTS

Electrical installations shall conform to IEEE C2, NFPA 70, and requirements specified herein.

1.12 INSTRUCTION TO GOVERNMENT PERSONNEL

Where specified in the technical sections, furnish the services of competent instructors to give full instruction to designated Government personnel in the adjustment, operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work. Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section.

PART 2 PRODUCTS

2.1 FACTORY APPLIED FINISH

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test and the additional requirements specified in the technical sections.

PART 3 EXECUTION

3.1 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in the section specifying the associated electrical equipment.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 05 48.00 10

SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT

10/07

PART 1 GENERAL

1.1 REFERENCES
1.2 SYSTEM DESCRIPTION
1.2.1 General Requirements
1.2.2 Electrical Equipment
1.2.3 Electrical Systems
1.2.4 Contractor Designed Bracing
1.2.5 Conduits Requiring No Special Seismic Restraints
1.3 EQUIPMENT REQUIREMENTS
1.3.1 Rigidly Mounted Equipment
1.4 SUBMITTALS

PART 2 PRODUCTS

PART 3 EXECUTION

-- End of Section Table of Contents --

SECTION 26 05 48.00 10

SEISMIC PROTECTION FOR ELECTRICAL EQUIPMENT
10/07

PART 1 GENERAL

1.1 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 INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 325 (2011) Steel Construction Manual

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04 (2013) Seismic Design for Buildings

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

The requirements for seismic protection measures described in this section shall be applied to the electrical equipment and systems listed below.

1.2.2 Electrical Equipment

Electrical equipment shall include the following items to the extent required on the drawings or in other sections of these specifications:

Constant Current Regulator/Dry Type Trasformer

1.2.3 Electrical Systems

The following electrical systems shall be installed as required on the drawings and other sections of these specifications and shall be seismically protected in accordance with this specification: dry type transformers and constant current regulators.

1.2.4 Contractor Designed Bracing

Submit copies of the Design Calculations with the Drawings. Calculations shall be approved, certified, stamped and signed by a Registered Professional Engineer. Calculations shall verify the capability of structural members to which floor mounting bolts are attached for carrying the load. Resistance to lateral forces induced by earthquakes shall be accomplished without consideration of friction resulting from gravity loads. UFC 3-310-04 uses parameters for the building, not for the equipment in the building; therefore, corresponding adjustments to the formulas shall be required. Loadings determined using UFC 3-310-04 are based on strength design; therefore, AISC 325 shall be used for the design. Develop the bracing for the following electrical equipment and

systems: dry type transformers and constant current regulators.

1.2.5 Conduits Requiring No Special Seismic Restraints

Seismic restraints may be omitted from electrical conduit less than 2-1/2 inches trade size or surface mounted. All other interior conduit, shall be seismically protected as specified.

1.3 EQUIPMENT REQUIREMENTS

Submit detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall be complete in detail, indicating thickness, type, grade, class of metal, and dimensions; and shall show construction details, reinforcement, anchorage, and installation with relation to the building construction. Submit copies of the design calculations with the detail drawings. Calculations shall be stamped by a registered engineer and shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

1.3.1 Rigidly Mounted Equipment

The following specific items of equipment: to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in UFC 3-310-04. Each item of rigid electrical equipment shall be entirely located and rigidly attached on the bottom only.

Transformers

Constant Current Regulators

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Equipment Requirements

SD-03 Product Data

Equipment Requirements; G
Contractor Designed Bracing; G

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 12 21

SINGLE-PHASE PAD-MOUNTED TRANSFORMERS

11/13

PART 1 GENERAL

1.1 REFERENCES
1.2 DEFINITIONS
1.3 SUBMITTALS
1.3.1 Reduced Submittal Requirements
1.4 QUALITY ASSURANCE
1.4.1 Pad-Mounted Transformer Drawings
1.4.2 Regulatory Requirements
1.4.3 Standard Products
1.4.3.1 Alternative Qualifications
1.4.3.2 Material and Equipment Manufacturing Date
1.5 MAINTENANCE
1.5.1 Additions to Operation and Maintenance Data

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION
2.2 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS (DEAD-FRONT)
2.2.1 Compartment Construction
2.2.1.1 High Voltage
2.2.1.2 Low Voltage
2.2.2 Transformer
2.2.2.1 Specified Transformer Efficiencies
2.3 INSULATING LIQUID
2.4 LIQUID-FILLED TRANSFORMER NAMEPLATES
2.5 CORROSION PROTECTION
2.6 WARNING SIGNS
2.7 GROUNDING AND BONDING
2.8 CAST-IN-PLACE CONCRETE
2.9 SOURCE QUALITY CONTROL
2.9.1 Design Tests
2.9.2 Routine and Other Tests

PART 3 EXECUTION

3.1 INSTALLATION
3.2 GROUNDING
3.2.1 Grounding Electrodes
3.2.2 Pad-Mounted Transformer Grounding
3.2.3 Connections
3.2.4 Grounding and Bonding Equipment
3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES
3.4 FIELD APPLIED PAINTING
3.5 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES
3.5.1 Cast-In-Place Concrete

3.5.2 Sealing
3.6 FIELD QUALITY CONTROL
3.6.1 Performance of Acceptance Checks and Tests
3.6.1.1 Pad-Mounted Transformers
3.6.1.2 Grounding System
3.6.1.3 Surge Arresters, Medium- and High-Voltage
3.6.2 Follow-Up Verification

-- End of Section Table of Contents --

SECTION 26 12 21

SINGLE-PHASE PAD-MOUNTED TRANSFORMERS
11/13

PART 1 GENERAL

1.1 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 A240/A240M	(2015a) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM D1535	(2014) Specifying Color by the Munsell System
ASTM D877/D877M	(2013) Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
ASTM D92	(2012b) Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D97	(2012) Pour Point of Petroleum Products

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2006; INT 1 2011) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE C2	(2012; Errata 1 2012; INT 1-4 2012; Errata 2 2013; INT 5-7 2013; INT 8-10 2014; INT 11 2015) National Electrical Safety Code
IEEE C37.47	(2011) Standard for High Voltage Current-Limiting Type Distribution Class Fuses and Fuse Disconnecting Switches
IEEE C57.12.00	(2010) Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.12.25	(1990) Standard for Transformers - Pad-Mounted, Compartmental-Type,

	Self-Cooled, Single-Phase Distribution Transformers With Separable Insulated High-Voltage Connectors; High Voltage, 34,500 Grdy/ 19,920 Volts and Below; Low Voltage, 240/120 Volts; 167 kVa and Smaller Requirements
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.12.29	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments
IEEE C57.12.80	(2010) Standard Terminology for Power and Distribution Transformers
IEEE C57.12.90	(2010) Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers
IEEE C57.98	(2011) Guide for Transformer Impulse Tests
IEEE C62.11	(2012) Standard for Metal-Oxide Surge Arresters for Alternating Current Power Circuits (>1kV)
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD)

OECD Test 203	(1992) Fish Acute Toxicity Test

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 712-C-98-075	(1998) Fate, Transport and Transformation Test Guidelines - OPPTS 835.3100- "Aerobic Aquatic Biodegradation"
EPA 821-R-02-012	(2002) Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

10 CFR 431	Energy Efficiency Program for Certain Commercial and Industrial Equipment

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Grounding and Bonding Equipment

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00.

SD-02 Shop Drawings

Pad-mounted transformer drawings; G

SD-03 Product Data

Single-phase pad-mounted transformers (dead-front); G

Include manufacturer's information for each component, device, insulating fluid, and accessory provided with the transformer.

SD-06 Test Reports

Acceptance checks and tests; G

Submit reports, including acceptance criteria and limits for each test in accordance with NETA ATS "Test Values".

SD-07 Certificates

Transformer efficiencies; G

Submit certification, including supporting calculations, from the manufacturer indicating conformance with the paragraph entitled "Specified Transformer Efficiencies."

SD-09 Manufacturer's Field Reports

Pad-mounted transformer design tests; G

Pad-mounted transformer routine and other tests; G

SD-10 Operation and Maintenance Data

Transformer, Data Package 5; G

Submit operation and maintenance data as specified herein.

1.3.1 Reduced Submittal Requirements

Transformers designed and manufactured by ABB in Jefferson City, MO; by Cooper Power Systems in Waukesha, WI; by ERMCO in Dyersburg, TN; or by Howard Industries in Laurel, MS need not submit the entire submittal package requirements of this contract. Instead, submit the following items:

a. A certification, signed by the manufacturer, stating that the manufacturer will meet the technical requirements of this specification.

b. An outline drawing of the transformer with devices identified (paragraph entitled "Pad-Mounted Transformer Drawings", item a).

c. ANSI nameplate data of the transformer (paragraph entitled "Pad-Mounted Transformer Drawings", item b).

d. Provide operation and maintenance manuals required by submittal item "SD-10 Operation and Maintenance Data".

1.4 QUALITY ASSURANCE

1.4.1 Pad-Mounted Transformer Drawings

Include the following as a minimum:

a. An outline drawing, including front, top, and side views.

b. ANSI nameplate data.

c. One-line diagram, including switch(es) and fuses.

d. Manufacturer's published time-current curves (on full size logarithmic paper) of the transformer high side fuse.

1.4.2 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.3 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required,

provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.3.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.5 MAINTENANCE

1.5.1 Additions to Operation and Maintenance Data

In addition to requirements of Data Package 5, include the following on the actual transformer provided:

a. An instruction manual with pertinent items and information highlighted.

b. An outline drawing, front, top, and side views.

c. Prices for spare parts and supply list.

d. Routine and field acceptance test reports.

e. Fuse curves for primary fuses.

f. Actual nameplate diagram.

g. Date of purchase.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be pad-mounted transformers and related accessories are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.2 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS (DEAD-FRONT)

IEEE C57.12.25, IEEE C57.12.28 and as specified herein.

2.2.1 Compartment Construction

a. Two compartment: Provide high- and low-voltage compartments separated by steel isolating barriers extending the full height and depth of the compartments. Compartment doors:

1. Hinged lift-off type with stop in open position and three-point latching.

2. High voltage door fastening accessible only after the low voltage

door has been opened.

2.2.1.1 High Voltage

High-voltage portion contains: the incoming line, insulated high-voltage load-break connectors, bushing well inserts, feed-through inserts, two high-voltage bushing wells configured for loop feed application, load-break switch handle(s), access to oil-immersed fuses, dead-front surge arrester, tap changer handle, connector parking stands with insulated standoff bushings, protective caps, and ground pad.

a. Bushing well inserts and feed-through inserts: IEEE 386, 200 amperes, 15 kV class. Provide a bushing well insert for each bushing well unless indicated otherwise. Provide feed-through inserts as indicated.

b. One-piece bushings: IEEE 386, 600 amperes, 15 kV Class.

c. Load-break switch: Radial-feed oil-immersed type rated at 15 kV, 95 kV BIL, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12,000 rms amperes symmetrical. Locate the switch handle in the high-voltage compartment.

d. Provide bayonet oil-immersed, expulsion fuses in series with oil-immersed, partial-range, current-limiting fuses. The bayonet fuse links sense both high currents and high oil temperature in order to provide thermal protection to the transformer. Coordinate transformer protection with expulsion fuse clearing low-current faults and current-limiting fuse clearing high-current faults beyond the interrupting rating of the expulsion fuse. Include an oil retention valve inside the bayonet assembly housing, which closes when the fuse holder is removed, and an external drip shield to minimize oil spills. Display a warning label adjacent to the bayonet fuse(s) cautioning against removing or inserting fuses unless the transformer has been de-energized and the tank pressure has been released.

   Bayonet fuse assembly: 150 kV BIL.

   Oil-immersed current-limiting fuses: IEEE C37.47; 50,000 rms amperes symmetrical interrupting rating at the system voltage specified. Connect current-limiting fuses ahead of the radial-feed load-break switch.

e. Surge arresters: IEEE C62.11, rated 3 kV, fully shielded, dead-front metal-oxide-varistor, elbow type with resistance-graded gap suitable for plugging into inserts as indicated.

f. Parking stands: Provide a parking stand near each bushing well. Provide insulated standoff bushings for parking of energized load-break connectors on parking stands.

g. Protective caps: IEEE 386, 200 amperes, 15 kV class. Provide insulated protective caps (not shipping caps) for insulating and sealing out moisture from unused bushing well inserts and insulated standoff bushings.

2.2.1.2 Low Voltage

Low-voltage portion contains: low-voltage bushings with NEMA spade terminals, accessories, stainless steel or laser-etched anodized aluminum

diagrammatic transformer nameplate, and ground pad.

a. Include the following accessories: drain plug, fill plug, pressure relief device and a liquid level sight gage.

2.2.2 Transformer

a. Less-flammable liquid-insulated, primary 4,160 V voltage, connected line-to-line, two winding, 60 hertz, 65 degrees C rise above a 30 degrees C average ambient, self-cooled type.

b. Rated 50 kVA with characteristics per the following table:

NAME	LOCATION	kVA	Voltage
T1	Glideslope/FLOI	50	240/120

c. Tap changer: externally operated, manual type for changing tap setting when the transformer is de-energized. Provide four 2.5 percent full capacity taps, two above and two below 4,160 V rated primary voltage. Indicate which tap setting is in use, clearly visible when the compartment is opened.

d. Minimum tested percent impedance at 85 degrees C:

2.50 for units rated 25 kVA and below
2.87 for units rated 37.5 kVA to 100 kVA
4.03 for 167 kVA rated units

e. Comply with the following audible sound level limits:

kVA	DECIBELS (MAX)
10	48
15	48
25	48
37.5	48
50	48
75	51
100	51
167	55

f. Include:

1. Lifting lugs and provisions for jacking under base, with base construction suitable for using rollers or skidding in any direction.

2. Insulated low-voltage neutral bushings with NEMA spade terminals and with removable ground strap.

3. Provide transformer top with an access handhole.

4. kVA rating conspicuously displayed using 3 inch high yellow letters on its enclosure.

2.2.2.1 Specified Transformer Efficiencies

Provide transformer efficiency calculations utilizing the actual no-load and load loss values obtained during the routine tests performed on the actual transformer prepared for this project. Reference no-load losses (NLL) at 20 degrees C. Reference load losses (LL) at 55 degrees C and at 50 percent of the nameplate load. The transformer is not acceptable if the calculated transformer efficiency is less than the efficiency indicated in the "KVA / Efficiency" table below. The table is based on requirements contained within 10 CFR 431, Subpart K.

kVA	EFFICIENCY (percent)
10	98.62
15	98.76
25	98.91
37.5	99.01
50	99.08
75	99.17
100	99.23
167	99.25

2.3 INSULATING LIQUID

a. Less-flammable transformer liquids: NFPA 70 and FM APP GUIDE for less-flammable 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 D877/D877M. Provide identification of transformer as "non-PCB" and "manufacturer's name and type of fluid" on the nameplate.

Provide a fluid that is a biodegradable, electrical insulating, and cooling liquid classified by UL and approved by FM as "less flammable" with the following properties:

1. Pour point: ASTM D97, less than -15 degree C.

2. Aquatic biodegradation: EPA 712-C-98-075, 100 percent.

3. Trout toxicity: OECD Test 203, zero mortality of EPA 821-R-02-012, pass.

2.4 LIQUID-FILLED TRANSFORMER NAMEPLATES

Provide nameplate information in accordance with IEEE C57.12.00 and as modified or supplemented by this section.

2.5 CORROSION PROTECTION

Provide entire transformer assembly, including tank and radiator, base, enclosure, fabricated of stainless steel conforming to ASTM A240/A240M, Type 304 or 304L. Form enclosure of stainless steel sheets.

Paint entire transformer assembly Munsell 7GY3.29/1.5 green, with paint coating system complying with IEEE C57.12.28 and IEEE C57.12.29 regardless of base, cabinet, and tank material. The Munsell color notation is specified in ASTM D1535.

2.6 WARNING SIGNS

Provide warning signs for the enclosures of pad-mounted transformers having a nominal rating exceeding 600 volts.

a. When the enclosure integrity of such equipment is specified to be in accordance with IEEE C57.12.28 or IEEE C57.12.29, such as for pad-mounted transformers, provide self-adhesive warning signs (decals, Panduit No. PPSO710D72 or approved equal) on the outside of the high voltage compartment door(s), with nominal dimensions of 7 by 10 inches with the legend "DANGER HIGH VOLTAGE" printed in two lines of nominal 2 inch high letters. Include the word "DANGER" in white letters on a red background and the words "HIGH VOLTAGE" in black letters on a white background.

Provide arc flash warning label for the enclosure of pad-mounted transformers. Locate this self-adhesive warning label on the outside of the high voltage compartment side warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.7 GROUNDING AND BONDING

UL 467. Provide grounding and bonding as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.8 CAST-IN-PLACE CONCRETE

Provide concrete associated with electrical work for other than encasement of underground ducts rated for 4000 psi minimum 28-day compressive strength unless specified otherwise. Conform to the requirements of Section 03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE.

2.9 SOURCE QUALITY CONTROL

2.9.1 Design Tests

IEEE C57.12.00, and IEEE C57.12.90. Section 5.1.2 in IEEE C57.12.80 states that "design tests are made only on representative apparatus of basically the same design." Submit design test reports (complete with test data, explanations, formulas, and results), in the same submittal package as the catalog data and drawings for the specified transformer, with design tests performed prior to the award of this contract.

a. Tests: certified and signed by a registered professional engineer.

b. Temperature rise: "Basically the same design" for the temperature rise test means a pad-mounted transformer with the same coil construction (such as wire wound primary and sheet wound secondary), the same kVA,

the same cooling type (ONAN), the same temperature rise rating, and the same insulating liquid as the transformer specified.

c. Lightning impulse: "Basically the same design" for the lightning impulse dielectric test means a pad-mounted transformer with the same BIL, the same coil construction (such as wire wound primary and sheet wound secondary), and a tap changer, if specified. Design lightning impulse tests includes the primary windings only of that transformer.

1. IEEE C57.12.90, paragraph 10.3 entitled "Lightning Impulse Test Procedures," and IEEE C57.98.

2. State test voltage levels.

3. Provide photographs of oscilloscope display waveforms or plots of digitized waveforms with test report.

d. Lifting and moving devices: "Basically the same design" requirement for the lifting and moving devices test means a test report confirming that the lifting device being used is capable of handling the weight of the specified transformer in accordance with IEEE C57.12.25.

e. Pressure: "Basically the same design" for the pressure test means a pad-mounted transformer with a tank volume within 30 percent of the tank volume of the transformer specified.

f. Short circuit: "Basically the same design" for the short circuit test means a pad-mounted transformer with the same kVA as the transformer specified.

2.9.2 Routine and Other Tests

IEEE C57.12.00. Routine and other tests: performed by the manufacturer on the actual transformer prepared for this project to ensure that the design performance is maintained in production. Submit test reports, by serial number and receive approval before delivery of equipment to the project site. Required tests include:

a. Polarity.

b. Ratio.

c. No-load losses (NLL) and excitation current.

d. Load losses (LL) and impedance voltage.

e. Dielectric.

1. Impulse.

2. Applied voltage.

3. Induced voltage.

f. Leak.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Pad-Mounted Transformer Grounding

Provide a ground ring around the transformer with 4/0 AWG bare copper. Provide four ground rods in the ground ring, one per corner. Install the ground rods at least 10 feetapart from each other.Provide separate copper grounding conductors and connect them to the ground loop as indicated. When work in addition to that indicated or specified is required to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect pad-mounted transformer furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.4 FIELD APPLIED PAINTING

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.5 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

Remove existing transformer and mount transformer on new concrete slab:

a. Unless otherwise indicated, provide the slab with dimensions at least 8 inches thick.

b. Place slab on a 6 inch thick, well-compacted gravel base.

c. Install slab such that top of concrete slab is approximately 4 inches above the finished grade with gradual slope for drainage.

d. Provide edges above grade with 1 inch chamfer.

e. Provide slab of adequate size to project at least 2 feet-0 inches beyond the equipment.

Stub up conduits, with bushings, 2 inches into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.5.1 Cast-In-Place Concrete

Provide cast-in-place concrete work in accordance with the requirements of Section 03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE.

3.5.2 Sealing

When the installation is complete, seal all entries into the equipment enclosure with an approved sealing method. Provide seals of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

3.6 FIELD QUALITY CONTROL

3.6.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.6.1.1 Pad-Mounted Transformers

a. Visual and mechanical inspection.

1. Compare equipment nameplate information with specifications and approved shop drawings.

2. Inspect physical and mechanical condition. Check for damaged or cracked insulators and leaks.

3. Inspect anchorage, alignment, and grounding.

4. Verify the presence of PCB content labeling.

5. Verify the bushings and transformer interiors are clean.

6. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

7. Verify correct liquid level in tanks.

8. Verify that positive pressure is maintained on gas-blanketed transformers.

9. Perform specific inspections and mechanical tests as recommended by manufacturer.

10. Verify correct equipment grounding.

11. Verify the presence of transformer surge arresters.

b. Electrical tests.

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter.

2. Verify proper secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading.

3.6.1.2 Grounding System

a. Visual and mechanical inspection.

1. Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests.

1. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

2. Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.6.1.3 Surge Arresters, Medium- and High-Voltage

a. Visual and mechanical inspection.

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical and mechanical condition.

3. Inspect anchorage, alignment, grounding, and clearances.

4. Verify the arresters are clean.

5. Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

6. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.

b. Electrical tests.

1. Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

2. Perform an insulation-resistance test on each arrester, phase terminal-to-ground.

3. Test grounding connection.

3.6.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, notify the Contracting Officer 5 working days in advance of the dates and times of checking and testing.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM

02/14

PART 1 GENERAL

1.1 REFERENCES
1.2 DEFINITIONS
1.3 SUBMITTALS
1.4 QUALITY ASSURANCE
1.4.1 Regulatory Requirements
1.4.2 Standard Products
1.4.2.1 Alternative Qualifications
1.4.2.2 Material and Equipment Manufacturing Date
1.5 WARRANTY

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT
2.2 CONDUIT AND FITTINGS
2.2.1 Rigid Metallic Conduit
2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit
2.2.2 Rigid Nonmetallic Conduit
2.2.3 Intermediate Metal Conduit (IMC)
2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)
2.2.5 Flexible Metal Conduit
2.2.5.1 Liquid-Tight Flexible Metal Conduit, Steel
2.2.6 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit
2.2.6.1 Fittings for Rigid Metal Conduit and IMC
2.2.6.2 Fittings for EMT
2.2.7 Fittings for Rigid Nonmetallic Conduit
2.3 CABINETS, JUNCTION BOXES, AND PULL BOXES
2.4 WIRES AND CABLES
2.4.1 Conductors
2.4.1.1 Equipment Manufacturer Requirements
2.4.1.2 Minimum Conductor Sizes
2.4.2 Color Coding
2.4.2.1 Ground and Neutral Conductors
2.4.2.2 Ungrounded Conductors
2.4.3 Insulation
2.4.4 Bonding Conductors
2.5 SPLICES AND TERMINATION COMPONENTS
2.6 SWITCHES
2.6.1 Disconnect Switches
2.7 PANELBOARDS
2.7.1 Enclosure
2.7.2 Panelboard Buses
2.7.3 Circuit Breakers
2.7.3.1 Multipole Breakers
2.8 ENCLOSED CIRCUIT BREAKERS

2.9 TRANSFORMERS
2.9.1 Specified Transformer Efficiency
2.10 GROUNDING AND BONDING EQUIPMENT
2.10.1 Ground Rods
2.10.2 Ground Bus
2.11 MANUFACTURER'S NAMEPLATE
2.12 FIELD FABRICATED NAMEPLATES
2.13 WARNING SIGNS
2.14 WIREWAYS
2.15 SURGE PROTECTIVE DEVICES
2.16 FACTORY APPLIED FINISH
2.17 SOURCE QUALITY CONTROL
2.17.1 Transformer Factory Tests

PART 3 EXECUTION

3.1 INSTALLATION
3.1.1 Underground Service
3.1.2 Service Entrance Identification
3.1.3 Conduit Installation
3.1.3.1 Restrictions Applicable to EMT
3.1.3.2 Restrictions Applicable to Nonmetallic Conduit
3.1.3.3 Restrictions Applicable to Flexible Conduit
3.1.3.4 Conduit for Circuits Rated Greater Than 600 Volts
3.1.3.5 Conduit Support
3.1.3.6 Directional Changes in Conduit Runs
3.1.3.7 Locknuts and Bushings
3.1.3.8 Flexible Connections
3.1.4 Boxes, Outlets, and Supports
3.1.4.1 Boxes
3.1.4.2 Pull Boxes
3.1.5 Mounting Heights
3.1.6 Conductor Identification
3.1.7 Splices
3.1.8 Grounding and Bonding
3.1.8.1 Ground Rods
3.1.8.2 Grounding Connections
3.1.8.3 Resistance
3.1.9 Equipment Connections
3.1.10 Repair of Existing Work
3.1.10.1 Workmanship
3.1.10.2 Existing Concealed Wiring to be Removed
3.1.10.3 Removal of Existing Electrical Distribution System
3.1.10.4 Continuation of Service
3.1.11 Surge Protective Devices
3.2 FIELD FABRICATED NAMEPLATE MOUNTING
3.3 WARNING SIGN MOUNTING
3.4 FIELD APPLIED PAINTING
3.5 FIELD QUALITY CONTROL
3.5.1 Devices Subject to Manual Operation
3.5.2 600-Volt Wiring Test
3.5.3 Transformer Tests
3.5.4 Grounding System Test

-- End of Section Table of Contents --

SECTION 26 20 00

INTERIOR DISTRIBUTION SYSTEM
02/14

PART 1 GENERAL

1.1 REFERENCES

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

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D709	(2013) Laminated Thermosetting Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE C2	(2012; Errata 1 2012; INT 1-4 2012; Errata 2 2013; INT 5-7 2013; INT 8-10 2014; INT 11 2015) National Electrical Safety Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C80.1	(2005) American National Standard for Electrical Rigid Steel Conduit (ERSC)
ANSI C80.3	(2005) American National Standard for Electrical Metallic Tubing (EMT)
NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA KS 1	(2013) Enclosed and Miscellaneous

	Distribution Equipment Switches (600 V Maximum)
NEMA ST 20	(1992; R 1997) Standard for Dry-Type Transformers for General Applications
NEMA TC 14	(2002) Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2015) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TP 1	(2002) Guide for Determining Energy Efficiency for Distribution Transformers
NEMA Z535.4	(2011) American National Standard for Product Safety Signs and Labels

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 70E	(2015; ERTA 1 2015) Standard for Electrical Safety in the Workplace
NFPA 780	(2014) Standard for the Installation of Lightning Protection Systems

UNDERWRITERS LABORATORIES (UL)

UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 1449	(2014;Reprint Mar 2015) Surge Protective Devices
UL 360	(2013; Reprint Jan 2015) Liquid-Tight Flexible Steel Conduit
UL 44	(2014; Reprint Feb 2015) Thermoset-Insulated Wires and Cables
UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 486C	(2013; Reprint Feb 2014) Splicing Wire Connectors
UL 489	(2013; Reprint Mar 2014) Molded-Case

	Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures
UL 50	(2007; Reprint Apr 2012) Enclosures for Electrical Equipment, Non-environmental Considerations
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514B	(2012; Reprint Nov 2014) Conduit, Tubing and Cable Fittings
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 651	(2011; Reprint May 2014) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 67	(2009; Reprint Apr 2015) Standard for Panelboards
UL 797	(2007; Reprint Dec 2012) Electrical Metallic Tubing -- Steel
UL 83	(2014) Thermoplastic-Insulated Wires and Cables
UL 869A	(2006) Reference Standard for Service Equipment
UL 870	(2008; Reprint Feb 2013) Standard for Wireways, Auxiliary Gutters, and Associated Fittings

1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00.

SD-02 Shop Drawings

Panelboards; G

Transformers; G

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, accessories, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and

indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices.

Wireways; G

SD-03 Product Data

Circuit breakers; G

Switches; G

Transformers; G

Enclosed circuit breakers; G

Surge protective devices; G

Include performance and characteristic curves.

SD-06 Test Reports

600-volt wiring test; G

Grounding system test; G

Transformer tests; G

SD-09 Manufacturer's Field Reports

Transformer factory tests

1.4 QUALITY ASSURANCE

1.4.1 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" or "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.4.2 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.2.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.2.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable.

1.5 WARRANTY

Provide equipment items supported by service organizations that are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

As a minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70 for all materials, equipment, and devices.

2.2 CONDUIT AND FITTINGS

Conform to the following:

2.2.1 Rigid Metallic Conduit

2.2.1.1 Rigid, Threaded Zinc-Coated Steel Conduit

ANSI C80.1, UL 6.

2.2.2 Rigid Nonmetallic Conduit

PVC Type EPC-80 in accordance with NEMA TC 2,UL 651, or fiberglass conduit, in accordance with NEMA TC 14.

2.2.3 Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

2.2.4 Electrical, Zinc-Coated Steel Metallic Tubing (EMT)

UL 797, ANSI C80.3.

2.2.5 Flexible Metal Conduit

2.2.5.1 Liquid-Tight Flexible Metal Conduit, Steel

UL 360.

2.2.6 Fittings for Metal Conduit, EMT, and Flexible Metal Conduit

UL 514B. Ferrous fittings: cadmium- or zinc-coated in accordance with UL 514B.

2.2.6.1 Fittings for Rigid Metal Conduit and IMC

Threaded-type. Split couplings unacceptable.

2.2.6.2 Fittings for EMT

Steel compression type.

2.2.7 Fittings for Rigid Nonmetallic Conduit

NEMA TC 3 for PVC, and UL 514B.

2.3 CABINETS, JUNCTION BOXES, AND PULL BOXES

Volume greater than 100 cubic inches, UL 50, hot-dip, zinc-coated, if sheet steel.

2.4 WIRES AND CABLES

Provide wires and cables in accordance applicable requirements of NFPA 70 and UL for type of insulation, jacket, and conductor specified or indicated. Do not use wires and cables manufactured more than 12 months prior to date of delivery to site.

2.4.1 Conductors

Provide the following:

a. Conductor sizes and capacities shown are based on copper, unless indicated otherwise.

b. Conductors No. 8 AWG and larger diameter: stranded.

c. Conductors No. 10 AWG and smaller diameter: solid.

d. Conductors for remote control, alarm, and signal circuits, classes 1, 2, and 3: stranded unless specifically indicated otherwise.

e. All conductors: copper.

2.4.1.1 Equipment Manufacturer Requirements

When manufacturer's equipment requires copper conductors at the terminations or requires copper conductors to be provided between components of equipment, provide copper conductors or splices, splice boxes, and other work required to satisfy manufacturer's requirements.

2.4.1.2 Minimum Conductor Sizes

Provide minimum conductor size in accordance with the following:

a. Branch circuits: No. 12 AWG.

b. Class 1 remote-control and signal circuits: No. 14 AWG.

c. Class 2 low-energy, remote-control and signal circuits: No. 16 AWG.

d. Class 3 low-energy, remote-control, alarm and signal circuits: No. 22 AWG.

2.4.2 Color Coding

Provide color coding for service, feeder, branch, control, and signaling circuit conductors.

2.4.2.1 Ground and Neutral Conductors

Provide color coding of ground and neutral conductors as follows:

a. Grounding conductors: Green.

b. Neutral conductors: White.

c. Exception, where neutrals of more than one system are installed in same raceway or box, other neutrals color coding: white with a different colored (not green) stripe for each.

2.4.2.2 Ungrounded Conductors

Provide color coding of ungrounded conductors in different voltage systems as follows:

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

b. 480/277 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

2.4.3 Insulation

Unless specified or indicated otherwise or required by NFPA 70, provide power and lighting wires rated for 600-volts, Type THWN/THHN conforming to UL 83 or Type XHHW conforming to UL 44, except that grounding wire may be type TW conforming to UL 83; remote-control and signal circuits: Type TW

or TF, conforming to UL 83. Where lighting fixtures require 90-degree Centigrade (C) conductors, provide only conductors with 90-degree C insulation or better.

2.4.4 Bonding Conductors

ASTM B1, solid bare copper wire for sizes No. 8 AWG and smaller diameter; ASTM B8, Class B, stranded bare copper wire for sizes No. 6 AWG and larger diameter.

2.5 SPLICES AND TERMINATION COMPONENTS

UL 486A-486B for wire connectors and UL 510 for insulating tapes. Connectors for No. 10 AWG and smaller diameter wires: insulated, pressure-type in accordance with UL 486A-486B or UL 486C (twist-on splicing connector). Provide solderless terminal lugs on stranded conductors.

2.6 SWITCHES

2.6.1 Disconnect Switches

NEMA KS 1. Provide heavy duty-type switches where indicated. Utilize Class R fuseholders and fuses for fused switches, unless indicated otherwise. Provide horsepower rated for switches serving as the motor-disconnect means. Provide switches in NEMA 4X stainless steel, enclosure as indicated per NEMA ICS 6.

2.7 PANELBOARDS

Provide panelboards in accordance with the following:

a. UL 67 and UL 50 having a short-circuit current rating of 10,000 amperes symmetrical minimum.

b. Panelboards: circuit breaker-equipped.

c. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.

d. "Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings.

e. Use of "Subfeed Breakers" is not acceptable unless specifically indicated otherwise.

f. Main breaker: "separately" mounted "above" or "below" branch breakers.

g. Where "space only" is indicated, make provisions for future installation of breakers.

h. Directories: indicate load served by each circuit in panelboard.

i. Directories: indicate source of service to panelboard (e.g., Panel PA served from Panel MDP).

j. Provide new directories for existing panels modified by this project as indicated.

k. Type directories and mount in holder behind transparent protective covering.

l. Panelboards: listed and labeled for their intended use.

m. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

n. UL 67 and UL 50.

o. Panelboards for use as service disconnecting: additionally conform to UL 869A.

p. Panelboards: circuit breaker-equipped.

q. Designed such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL.

r. Where "space only" is indicated, make provisions for future installation of breaker sized as indicated.

s. Directories: indicate load served by each circuit of panelboard.

t. Directories: indicate source of service (upstream panel, switchboard, motor control center, etc.) to panelboard.

u. Type directories and mount in holder behind transparent protective covering.

v. Panelboard nameplates: provided in accordance with paragraph FIELD FABRICATED NAMEPLATES.

2.7.1 Enclosure

Provide panelboard enclosure in accordance with the following:

a. UL 50.

b. Cabinets mounted outdoors or flush-mounted: hot-dipped galvanized after fabrication.

c. Cabinets: painted in accordance with paragraph PAINTING.

d. Outdoor cabinets: NEMA 3R raintight with a removable steel plate 1/4 inch thick in the bottom for field drilling for conduit connections.

e. Front edges of cabinets: form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front.

f. All cabinets: fabricated such that no part of any surface on the finished cabinet deviates from a true plane by more than 1/8 inch.

g. Holes: provided in the back of indoor surface-mounted cabinets, with outside spacers and inside stiffeners, for mounting the cabinets with a 1/2 inch clear space between the back of the cabinet and the wall surface.

h. Flush doors: mounted on hinges that expose only the hinge roll to view when the door is closed.

i. Each door: fitted with a combined catch and lock, except that doors over 24 inches long provided with a three-point latch having a knob with a T-handle, and a cylinder lock.

j. Keys: two provided with each lock, with all locks keyed alike.

k. Finished-head cap screws: provided for mounting the panelboard fronts on the cabinets.

2.7.2 Panelboard Buses

Support bus bars on bases independent of circuit breakers. Design main buses and back pans so that breakers may be changed without machining, drilling, or tapping. Provide isolated neutral bus in each panel for connection of circuit neutral conductors. Provide separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2.7.3 Circuit Breakers

UL 489, thermal magnetic-type having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker will be mounted. Breaker terminals: UL listed as suitable for type of conductor provided.

2.7.3.1 Multipole Breakers

Provide common trip-type with single operating handle. Design breaker such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.8 ENCLOSED CIRCUIT BREAKERS

UL 489. Individual molded case circuit breakers with voltage and continuous current ratings, number of poles, overload trip setting, and short circuit current interrupting rating as indicated. Enclosure type as indicated.

2.9 TRANSFORMERS

Provide transformers in accordance with the following:

a. NEMA ST 20, general purpose, dry-type, self-cooled, ventilated.

b. Provide transformers in NEMA 1 enclosure.

c. Transformer insulation system:

(1) 220 degrees C insulation system for transformers 15 kVA and greater, with temperature rise not exceeding 80 degrees C under full-rated load in maximum ambient of 40 degrees C.

(2) 180 degrees C insulation for transformers rated 10 kVA and less, with temperature rise not exceeding 80 degrees C under full-rated

load in maximum ambient of 40 degrees C.

d. Transformer of 80 degrees C temperature rise: capable of carrying continuously 130 percent of nameplate kVA without exceeding insulation rating.

e. Transformers: quiet type with maximum sound level at least 3 decibels less than NEMA standard level for transformer ratings indicated.

2.9.1 Specified Transformer Efficiency

Transformers, indicated and specified with: 480V primary, 80 degrees C or 115 degrees C temperature rise, kVA ratings of 37.5 to 100 for single phase or 30 to 500 for three phase, energy efficient type. Minimum efficiency, based on factory test results: not be less than NEMA Class 1 efficiency as defined by NEMA TP 1.

2.10 GROUNDING AND BONDING EQUIPMENT

2.10.1 Ground Rods

UL 467. Ground rods: copper-clad steel, with minimum diameter of 3/4 inch and minimum length 10 feet. Sectional ground rods are permitted.

2.10.2 Ground Bus

Copper ground bus: provided in the electrical equipment rooms as indicated.

2.11 MANUFACTURER'S NAMEPLATE

Provide on each item of equipment a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.12 FIELD FABRICATED NAMEPLATES

Provide field fabricated nameplates in accordance with the following:

a. ASTM D709.

b. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings.

c. Each nameplate inscription: identify the function and, when applicable, the position.

d. Nameplates: melamine plastic, 0.125 inch thick, white with black center core.

e. Provide red laminated plastic label with white center core where indicated.

f. Surface: matte finish. Corners: square. Accurately align lettering and engrave into the core.

g. Minimum size of nameplates: one by 2.5 inches.

h. Lettering size and style: a minimum of 0.25 inch high normal block

style.

2.13 WARNING SIGNS

Provide warning signs for flash protection in accordance with NFPA 70E and NEMA Z535.4 for switchboards, panelboards, industrial control panels, and motor control centers that are in other than dwelling occupancies and are likely to require examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electric arc flash hazards when warning signs are not provided by the manufacturer. Provide marking that is clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.14 WIREWAYS

UL 870. Material: steel galvanized 16 gauge for heights and depths up to 6 by 6 inches, and 14 gauge for heights and depths up to 12 by 12 inches. Provide in length required for the application with hinged-cover NEMA 1 enclosure per NEMA ICS 6.

2.15 SURGE PROTECTIVE DEVICES

Provide parallel type surge protective devices (SPD) which comply with UL 1449 at the service entrance, panelboards. Provide surge protectors in a NEMA 1 enclosure per NEMA ICS 6. Use Type 1 or Type 2 SPD and connect on the load side of a dedicated circuit breaker.

Provide the following modes of protection:

FOR SINGLE PHASE AND THREE PHASE WYE CONNECTED SYSTEMS-
Phase to phase (L-L)
Each phase to neutral (L-N)
Neutral to ground (N-G)
Phase to ground (L-G)

Provide SPDs per NFPA 780 for the lightning protection system.

Maximum L-N, L-G, and N-G Voltage Protection Rating:

600V for 120V, single phase system
600V for 120/240V, single phase system
600V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Maximum L-L Voltage Protection Rating:

1,200V for 120V, single phase system
1,200V for 120/240V, single phase system
1,200V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Provide SPDs. Maximum L-N, L-G, and N-G Voltage Protection Rating:

700V for 120V, single phase system
700V for 120/240V, single phase system
700V for 208Y/120V, three phase system
1,200V for 480Y/277V, three phase system

Maximum L-L Voltage Protection Rating:

1,200V for 120V, single phase system
1,200V for 120/240V, single phase system
1,200V for 208Y/120V, three phase system
2,000V for 480Y/277V, three phase system

The minimum MCOV (Maximum Continuous Operating Voltage) rating for L-N and L-G modes of operation: 120% of nominal voltage for 240 volts and below; 115% of nominal voltage above 240 volts to 480 volts.

2.16 FACTORY APPLIED FINISH

Provide factory-applied finish on electrical equipment in accordance with the following:

a. NEMA 250 corrosion-resistance test and the additional requirements as specified herein.

b. Interior and exterior steel surfaces of equipment enclosures: thoroughly cleaned followed by a rust-inhibitive phosphatizing or equivalent treatment prior to painting.

c. Exterior surfaces: free from holes, seams, dents, weld marks, loose scale or other imperfections.

d. Interior surfaces: receive not less than one coat of corrosion-resisting paint in accordance with the manufacturer's standard practice.

e. Exterior surfaces: primed, filled where necessary, and given not less than two coats baked enamel with semigloss finish.

f. Equipment located indoors: ANSI Light Gray.

g. Provide manufacturer's coatings for touch-up work and as specified in paragraph FIELD APPLIED PAINTING.

2.17 SOURCE QUALITY CONTROL

2.17.1 Transformer Factory Tests

Submittal: include routine NEMA ST 20 transformer test results on each transformer and also provide the results of NEMA "design" and "prototype" tests that were made on transformers electrically and mechanically equal to those specified.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations, including weatherproof locations and ducts, plenums and other air-handling spaces: conform to requirements of NFPA 70 and IEEE C2 and to requirements specified herein.

3.1.1 Underground Service

Underground service conductors and associated conduit: continuous from service entrance equipment to outdoor power system connection.

3.1.2 Service Entrance Identification

Service entrance disconnect devices, switches, and enclosures: labeled and identified as such.

3.1.3 Conduit Installation

Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project.

3.1.3.1 Restrictions Applicable to EMT

a. Do not install underground.

b. Do not encase in concrete, mortar, grout, or other cementitious materials.

c. Do not use in areas subject to severe physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.

d. Do not use outdoors.

3.1.3.2 Restrictions Applicable to Nonmetallic Conduit

a. PVC Schedule 80

(1) Do not use in areas where subject to severe physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, hospitals, power plants, missile magazines, and other such areas.

(2) Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.

(3) Do not use above grade, except where allowed in this section for rising through floor slab or indicated otherwise.

3.1.3.3 Restrictions Applicable to Flexible Conduit

Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

3.1.3.4 Conduit for Circuits Rated Greater Than 600 Volts

Rigid metal conduit.

3.1.3.5 Conduit Support

Support conduit by pipe straps, wall brackets, threaded rod conduit hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work. Threaded C-clamps may be used on rigid steel conduit

only. Do not weld conduits or pipe straps to steel structures. Do not exceed one-fourth proof test load for load applied to fasteners. Provide vibration resistant and shock-resistant fasteners attached to concrete ceiling. Do not cut main reinforcing bars for any holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Conduit and box systems: supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are placed. Do not share supporting means between electrical raceways and mechanical piping or ducts. Coordinate installationwith above-ceiling mechanical systems to assure maximum accessibility to all systems. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

3.1.3.6 Directional Changes in Conduit Runs

Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

3.1.3.7 Locknuts and Bushings

Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Provide locknuts with sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

3.1.3.8 Flexible Connections

Provide flexible steel conduit between 3 and 6 feet in length; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size: 1/2 inch diameter. Provide liquidtight flexible nonmetallic conduit in wet and damp locations for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

3.1.4 Boxes, Outlets, and Supports

Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways: cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, when surface mounted on interior walls exposed up to 7 feet above floors and walkways, and when specifically indicated. Boxes in other locations: sheet steel and nonmetallic boxes may be used with nonmetallic sheathed cable conduit system. Provide each box with volume required by NFPA 70 for number of conductors enclosed in box. Provide gaskets for cast-metal boxes installed in wet locations and boxes installed flush with outside of exterior

surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature; provide readily removable fixturesfor access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. Threaded studs driven in by powder charge and provided with lockwashers and nuts or nail-type nylon anchors may be used in lieu of wood screws, expansion shields, or machine screws. In open overhead spaces, cast boxes threaded to raceways need not be separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved-type fastener maximum 24 inches from box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

3.1.4.1 Boxes

Boxes for use with raceway systems: minimum 1 1/2 inches deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets: minimum 4 inches square, except that 4 by 2 inch boxes may be used where only one raceway enters outlet.

3.1.4.2 Pull Boxes

Construct of at least minimum size required by NFPA 70 of code-gauge galvanized sheet steel, except where cast-metal boxes are required in locations specified herein. Provide boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

3.1.5 Mounting Heights

Mount panelboards, enclosed circuit breakers, and disconnecting switches so height of operating handle at its highest position is maximum 78 inches above floor. Mount lighting switches 48 inches above finished floor. Mount other devices as indicated. Measure mounting heights of wiring devices and outlets in non-hazardous areas to center of device or outlet.

3.1.6 Conductor Identification

Provide conductor identification within each enclosure where tap, splice, or termination is made. For conductors No. 6 AWG and smaller diameter, provide color coding by factory-applied, color-impregnated insulation. For conductors No. 4 AWG and larger diameter, provide color coding by plastic-coated, self-sticking markers; colored nylon cable ties and plates; or heat shrink-type sleeves.

3.1.7 Splices

Make splices in accessible locations. Make splices in conductors No. 10 AWG and smaller diameter with insulated, pressure-type connector. Make splices in conductors No. 8 AWG and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

3.1.8 Grounding and Bonding

Provide in accordance with NFPA 70 and NFPA 780. Ground exposed, non-current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in metallic and nonmetallic raceways, and neutral conductor of wiring systems. Make ground connection to driven ground rods on exterior of building. Interconnect all grounding media in or on the structure to provide a common ground potential. This includes lightning protection, electrical service, telecommunications system grounds, as well as underground metallic piping systems. Use main size lightning conductors for interconnecting these grounding systems to the lightning protection system.

3.1.8.1 Ground Rods

Provide cone pointed ground rods. Measure the resistance to ground using the fall-of-potential method described in IEEE 81. Do not exceed 25 ohms under normally dry conditions for the maximum resistance of a driven ground. If the resultant resistance exceeds 25 ohms measured not less than 48 hours after rainfall, notify the Contracting Officer who will decide on the number of ground rods to add.

3.1.8.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, excepting specifically those connections for which access for periodic testing is required, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Provide tools and dies as recommended by the manufacturer. Use an embossing die code or other standard method to provide visible indication that a connector has been adequately compressed on the ground wire.

3.1.8.3 Resistance

Maximum resistance-to-ground of grounding system: do not exceed 5 ohms under dry conditions. Where resistance obtained exceeds 5 ohms, contact Contracting Officer for further instructions.

3.1.9 Equipment Connections

Provide power wiring for the connection of motors and control equipment under this section of the specification. Except as otherwise specifically noted or specified, automatic control wiring, control devices, and protective devices within the control circuitry are not included in this section of the specifications and are provided under the section specifying the associated equipment.

3.1.10 Repair of Existing Work

Perform repair of existing work, demolition, and modification of existing electrical distribution systems as follows:

3.1.10.1 Workmanship

Lay out work in advance. Exercise care where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, or other surfaces is necessary for proper installation, support, or anchorage of conduit, raceways, or other electrical work. Repair damage to buildings, piping, and equipment using skilled craftsmen of trades involved.

3.1.10.2 Existing Concealed Wiring to be Removed

Disconnect existing concealed wiring to be removed from its source. Remove conductors; cut conduit flush with floor, underside of floor, and through walls; and seal openings.

3.1.10.3 Removal of Existing Electrical Distribution System

Removal of existing electrical distribution system equipment includes equipment's associated wiring, including conductors, cables, exposed conduit, surface metal raceways, boxes, and fittings, back to equipment's power source as indicated.

3.1.10.4 Continuation of Service

Maintain continuity of existing circuits of equipment to remain. Maintain existing circuits of equipment energized. Restore circuits wiring and power which are to remain but were disturbed during demolition back to original condition.

3.1.11 Surge Protective Devices

Connect the surge protective devices in parallel to the power source, keeping the conductors as short and straight as practically possible. Maximum allowed lead length is 3 feet.

3.2 FIELD FABRICATED NAMEPLATE MOUNTING

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.3 WARNING SIGN MOUNTING

Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.4 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria.

3.5 FIELD QUALITY CONTROL

Furnish test equipment and personnel and submit written copies of test results. Give Contracting Officer 5 working days notice prior to each test.

3.5.1 Devices Subject to Manual Operation

Operate each device subject to manual operation at least five times, demonstrating satisfactory operation each time.

3.5.2 600-Volt Wiring Test

Test wiring rated 600 volt and less to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 500 volts to provide direct reading of resistance. Minimum resistance: 250,000 ohms.

3.5.3 Transformer Tests

Perform the standard, not optional, tests in accordance with the Inspection and Test Procedures for transformers, dry type, air-cooled, 600 volt and below; as specified in NETA ATS. Measure primary and secondary voltages for proper tap settings. Tests need not be performed by a recognized independent testing firm or independent electrical consulting firm.

3.5.4 Grounding System Test

Test grounding system to ensure continuity, and that resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to Contracting Officer, and indicate location of rods as well as resistance and soil conditions at time measurements were made.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM

11/13

PART 1 GENERAL

1.1 REFERENCES
1.2 RELATED REQUIREMENTS
1.2.1 Verification of Dimensions
1.2.2 System Requirements
1.2.3 Lightning Protection System Installers Documentation
1.3 SUBMITTALS
1.4 QUALITY ASSURANCE
1.4.1 Installation Drawings
1.4.1.1 Major Components
1.4.2 Component UL Listed and Labeled
1.4.3 Lightning Protection and Grounding System Test Plan
1.5 SITE CONDITIONS

PART 2 PRODUCTS

2.1 MATERIALS
2.1.1 Copper Only
2.2 COMPONENTS
2.2.1 Ground Rods
2.2.2 Connections and Terminations
2.2.3 Connector Fittings

PART 3 EXECUTION

3.1 INTEGRAL SYSTEM
3.1.1 Ground Connections
3.1.2 Grounding Electrodes
3.2 APPLICATIONS
3.3 RESTORATION
3.4 FIELD QUALITY CONTROL
3.4.1 Lightning Protection and Grounding System Test

-- End of Section Table of Contents --

SECTION 26 41 00

LIGHTNING PROTECTION SYSTEM
11/13

PART 1 GENERAL

1.1 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.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 780	(2014) Standard for the Installation of Lightning Protection Systems

UNDERWRITERS LABORATORIES (UL)

UL 467	(2007) Grounding and Bonding Equipment
UL 96	(2005; Reprint Mar 2015) Standard for Lightning Protection Components
UL Electrical Constructn	(2012) Electrical Construction Equipment Directory

1.2 RELATED REQUIREMENTS

1.2.1 Verification of Dimensions

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before making any departures from the design.

1.2.2 System Requirements

Provide a system furnished under this specification consisting of the latest UL Listed products of a manufacturer regularly engaged in production of lightning protection system components. Comply with NFPA 70, NFPA 780, and UL 96.

1.2.3 Lightning Protection System Installers Documentation

Provide documentation showing that the installer is certified with a commercial third-party inspection company whose sole work is lightning protection, or is a UL Listed Lightning Protection Installer. In either case, the documentation must show that they have completed and passed the requirements for certification or listing, and have a minimum of 2 years documented experience installing lightning protection systems for DoD projects of similar scope and complexity.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Each major component; G

SD-06 Test Reports

Lightning Protection and Grounding System Test Plan; G

Lightning Protection and Grounding System Test; G

SD-07 Certificates

Lightning Protection System Installers Documentation; G

Component UL Listed and Labeled; G

1.4 QUALITY ASSURANCE

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" or "must" has been substituted for "should" wherever it appears. Interpret references in these standards to "authority having jurisdiction," or words of similar meaning, to mean Contracting Officer.

1.4.1 Installation Drawings

1.4.1.1 Major Components

Submit detail drawings for each major component including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions.

1.4.2 Component UL Listed and Labeled

Submit proof of compliance that components are UL Listed and Labeled. Listing alone in UL Electrical Constructn, which is the UL Electrical Construction Directory, is not acceptable evidence. In lieu of Listed and Labeled, submit written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories.

1.4.3 Lightning Protection and Grounding System Test Plan

Provide a lightning protection and grounding system test plan. Detail both the visual inspection and electrical testing of the system and components in the test plan. Identify (number) the system test points/locations along with a listing or description of the item to be tested and the type of test to be conducted. As a minimum, include a sketch of the facility and surrounding lightning protection system as part of the specific test plan for each structure. Include the requirements specified in paragraph, "Testing of Integral Lightning Protection System" in the test plan.

1.5 SITE CONDITIONS

Confirm all details of work, verify all dimensions in field, and advise Contracting Officer of any discrepancy before performing work. Obtain prior approval of Contracting Officer before changing the design.

PART 2 PRODUCTS

2.1 MATERIALS

Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist which would cause corrosion of conductors, provide conductors with protective coatings, such as tin or lead, or oversize conductors. Where a mechanical hazard is involved, increase conductor size to compensate for the hazard or protect conductors. When metallic conduit or tubing is provided, electrically bond conductor to conduit or tubing at the upper and lower ends by clamp type connectors or welds (including exothermic). All lightning protection components, such as bonding plates, clips, connector fittings, and fasteners are to comply with the requirements of UL 96 classes as applicable.

2.1.1 Copper Only

Provide copper conductors, except where aluminum conductors are required for connection to aluminum equipment.

2.2 COMPONENTS

2.2.1 Ground Rods

Provide ground rods made of copper-clad steel conforming to conform to UL 467. Provide ground rods that are not less than 3/4 inch in diameter and 10 feet in length. Do not mix ground rods of copper-clad steel or solid copper on the job.

2.2.2 Connections and Terminations

Provide connectors for splicing conductors that conform to UL 96, class as applicable. Conductor connections can be made by clamps or welds (including exothermic). Provide style and size connectors required for the installation.

2.2.3 Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that conform to NFPA 780 and UL 96.

PART 3 EXECUTION

3.1 INTEGRAL SYSTEM

Provide a lightning protection system that meets the requirements of NFPA 780, including tie-ins to existing lightning protection systems. Lightning protection system consists of ground connections, and grounding electrodes and ground ring electrode conductor. Expose conductors on the structures except where conductors are required to be in protective sleeves. Bond secondary conductors with grounded metallic parts within the building. Make interconnections within side-flash distances at or below the level of the grounded metallic parts.

3.1.1 Ground Connections

Attach each down conductor and ground ring electrode to ground rods by welding (including exothermic), brazing, or compression. All connections to ground rods below ground level must be by exothermic weld connection or with a high compression connection using a hydraulic or electric compression tool to provide the correct circumferential pressure. Accessible connections above ground level and in test wells can be accomplished by mechanical clamping.

3.1.2 Grounding Electrodes

Extend driven ground rods vertically into the existing undisturbed earth for a distance of not less 10 feet. Set ground rods not less than 3 feet nor more than 8 feet, from the structure foundation, and at least beyond the drip line for the facility. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in IEEE 81. Maximum allowed resistance of a driven ground rod is 25 ohms, under normally dry conditions when a ground ring electrode is not used. Contact the Contracting Officer for direction on how to proceed when two of any three ground rods, driven not less than 10 feet into the ground, a minimum of 10 feet apart, and equally spaced around the perimeter, give a combined value exceeding 50 ohms immediately after having driven. For ground ring electrode, provide continuous No. 1/0 bare stranded copper cable. Lay ground ring electrode around the perimeter of the structure in a trench not less than 3 feet nor more than 8 feet from the nearest point of the structure foundation, and at least beyond the drip line for the facility. Install ground ring electrode to a minimum depth of 30 inches. Install a ground ring electrode in earth undisturbed by excavation, not earth fill, and do not locate beneath roof overhang, or wholly under paved areas or roadways where rainfall cannot penetrate to keep soil moist in the vicinity of the cable.

3.2 APPLICATIONS

3.3 RESTORATION

Where sod has been removed, place sod as soon as possible after completing the backfilling. Restore, to original condition, the areas disturbed by trenching, storing of dirt, cable laying, and other work. Overfill to accommodate for settling. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging or mulching in any restoration. Maintain disturbed surfaces and replacements until final acceptance.

3.4 FIELD QUALITY CONTROL

3.4.1 Lightning Protection and Grounding System Test

Test the lightning protection and grounding system to ensure continuity is not in excess of 1 ohm and that resistance to ground is not in excess of 25 ohms. Provide documentation for the measured values at each test point. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Include in the written report: locations of test points, measured values for continuity and ground resistances, and soil conditions at the time that measurements were made. Submit results of each test to the Contracting Officer.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 26 - ELECTRICAL

SECTION 26 56 20.00 10

AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS

10/07

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 QUALITY ASSURANCE
1.3.1 Code Compliance
1.3.2 Qualifications
1.3.3 Protection Plan
1.3.4 Prevention of Corrosion
1.3.4.1 Metallic Materials
1.3.4.2 Ferrous Metal Hardware
1.3.5 As-Built Drawings
1.4 PROJECT/SITE CONDITIONS
1.4.1 Altitude
1.4.2 Other

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION
2.2 MATERIALS AND EQUIPMENT
2.3 NAMEPLATES
2.4 ADDITIONAL REQUIREMENTS
2.4.1 Electrical Tape
2.4.2 Conduit, Conduit Fittings, and Boxes
2.4.2.1 Rigid Steel or Intermediate Metal Conduit (IMC) and Fittings
2.4.2.2 Flexible Metal Conduit
2.4.2.3 Outlet Boxes for Use with Steel Conduit, Rigid or Flexible
2.4.2.4 Plastic Duct for Concrete Encased Burial
2.4.2.5 Plastic Conduit for Direct Burial
2.4.2.6 Frangible Couplings and Adapters
2.4.3 Wire and Cable
2.4.3.1 Conductor Sizes
2.4.3.2 Low Voltage Wire and Cable
2.4.3.3 Wire and Cable for Airfield and Heliports
2.4.3.4 Cable Tags
2.4.4 Ground Rods
2.4.5 Lightning Arresters
2.4.6 Cable Connectors and Splices
2.4.7 Transformers
2.4.7.1 Encapsulated Isolation Transformers
2.4.8 Light Bases
2.4.9 Constant Current Regulator
2.4.10 LED Lamps and Filters
2.4.11 Transformer
2.4.12 Lighting Fixtures
2.5 AIRFIELD AND HELIPORT MARKINGS

2.6 LED RUNWAY END IDENTIFIER LIGHTS (REIL)
2.7 RUNWAY LIGHTING SYSTEM
2.7.1 LED Runway Edge Lights
2.7.2 LED Runway Threshold and End Lights
2.8 LED TAXIWAY LIGHTING SYSTEMS
2.8.1 LED Taxiway Edge Lights
2.8.2 Taxiway Guidance Signs
2.8.3 Hold Position Lights and Signs
2.9 GLIDE SLOPE INDICATOR
2.9.1 LED PAPI
2.10 SERIES CIRCUIT CUTOUTS
2.11 FACTORY COATINGS

PART 3 EXECUTION

3.1 EXAMINATION
3.2 GENERAL INSTALLATION REQUIREMENTS
3.3 CABLES, GENERAL REQUIREMENTS
3.3.1 Duct Line Installation
3.3.2 Direct-Burial Installation
3.3.2.1 Trenching for Direct Burial Conduits
3.3.3 Connection to Buildings
3.4 LOW-VOLTAGE CABLES
3.5 DUCT LINES FOR AIRFIELD LIGHTING CABLES
3.5.1 Requirements
3.5.2 Treatment
3.5.3 Non-encased Direct-Burial
3.5.4 Installation of Couplings
3.5.4.1 Plastic Duct
3.6 MANHOLES AND HANDHOLES
3.7 CABLE MARKERS
3.8 FRANGIBLE REQUIREMENTS
3.9 ELEVATED AIRFIELD AND HELIPORT LIGHTS
3.10 SEMIFLUSH AIRFIELD AND HELIPORT LIGHTS
3.11 ENCLOSURES IN DRILLED HOLES
3.11.1 Holes for Light Fixtures
3.12 FIXTURES AND WIRES INSTALLATION
3.12.1 General
3.13 SPLICES FOR AIRFIELD AND HELIPORT LIGHTING CABLE
3.13.1 Connectors
3.14 GROUNDING SYSTEMS
3.14.1 Counterpoise Installation
3.14.2 Fixture Grounding
3.15 WIND DIRECTION INDICATORS
3.16 ISOLATION TRANSFORMERS
3.17 RUNWAY AND TAXIWAY LIGHTING SYSTEMS
3.17.1 Runway and Taxiway Edge Lights
3.18 FIELD QUALITY CONTROL
3.18.1 Operating Test
3.18.2 Distribution Conductors, 600-Volt Class
3.18.3 Counterpoise System Test and Inspection
3.18.4 Progress Testing for Series Lighting Circuits
3.18.5 Electrical Acceptance Tests
3.18.5.1 Low-Voltage Continuity Tests
3.18.5.2 High-Voltage Insulation Resistance Tests
3.18.5.2.1 Test Procedure
3.18.5.2.2 Leakage Current
3.18.6 Constant Current Regulators
3.18.7 Regulator Electrical Tests

3.19 TRAINING
3.20 FINAL OPERATING TESTS
3.21 POSTED INSTRUCTIONS

-- End of Section Table of Contents --

SECTION 26 56 20.00 10

AIRFIELD AND HELIPORT LIGHTING AND VISUAL NAVIGATION AIDS
10/07

PART 1 GENERAL

1.1 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 A123/A123M	(2013) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2009) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A780/A780M	(2009; R 2015) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM D1654	(2008) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D709	(2013) Laminated Thermosetting Materials

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2012; Errata 1 2012; INT 1-4 2012; Errata 2 2013; INT 5-7 2013; INT 8-10 2014; INT 11 2015) National Electrical Safety Code

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2011) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2015) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 20	(2002; E 2004) Zinc-Rich Primers (Type I, Inorganic, and Type II, Organic)

U.S. FEDERAL AVIATION ADMINISTRATION (FAA)

FAA 6850.19	(1978) Frangible Coupling
FAA AC 150/5345-10	(2014; Rev H) Specification for Constant Current Regulators Regulator Monitors
FAA AC 150/5345-26	(2008; Rev D) FAA Specification for L-823 Plug and Receptacle, Cable Connectors
FAA AC 150/5345-28	(2005; Rev F) Precision Approach Path Indicator (PAPI) Systems
FAA AC 150/5345-42	(2013; Rev G) Specification for Airport Light Bases, Transformer Housings, Junction Boxes and Accessories
FAA AC 150/5345-44	(2007; Rev H) Specification for Runway and Taxiway Signs
FAA AC 150/5345-46	(2009; Rev D) Specification for Runway and Taxiway Light Fixtures
FAA AC 150/5345-47	(2005; Rev B) Specification for Series to Series Isolation Transformers for Airport Lighting Systems
FAA AC 150/5345-51	(2005; Rev A) Specification for Discharge-Type Flashing Light Equipment
FAA AC 150/5345-53D	(2012; Rev D) Specification for Airport Lighting Equipment Certification Program
FAA AC 150/5345-7	(2013; Rev F) Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
FAA E-2519	(1972; Rev A) Types I and II

UNDERWRITERS LABORATORIES (UL)

UL 1	(2005; Reprint Jul 2012) Standard for Flexible Metal Conduit
UL 1242	(2006; Reprint Mar 2014) Standard for Electrical Intermediate Metal Conduit -- Steel
UL 360	(2013; Reprint Jan 2015) Liquid-Tight Flexible Steel Conduit
UL 44	(2014; Reprint Feb 2015) Thermoset-Insulated Wires and Cables
UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514A	(2013) Metallic Outlet Boxes
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 797	(2007; Reprint Dec 2012) Electrical Metallic Tubing -- Steel
UL Electrical Constructn	(2012) Electrical Construction Equipment Directory

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Lighting and Visual Navigation Aids; G
As-Built Drawings

SD-03 Product Data

Materials and Equipment
Protection Plan
Training
Special Tools
List of Parts
Maintenance and Repair
Posted Instructions

SD-06 Test Reports

Field Quality Control
Visual Inspection

SD-07 Certificates

Qualifications
Materials and Equipment

SD-10 Operation and Maintenance Data

Operation and Maintenance Procedures; G

1.3 QUALITY ASSURANCE

1.3.1 Code Compliance

The installation shall comply with the requirements and recommendations of NFPA 70 and IEEE C2 and local codes where required.

1.3.2 Qualifications

a. Submit certification containing the names and the qualifications of persons recommended to perform the splicing and termination of medium-voltage cables approved for installation under this contract. The certification shall indicate that any person recommended to perform actual splicing and termination has been adequately trained in the proper techniques and has had at least 3 recent years of experience in splicing and terminating the same or similar types of cables approved for installation. Any person recommended by the Contractor may be required to perform a dummy or practice splice and termination, in the presence of the Contracting Officer, before being approved as a qualified installer of medium-voltage cables. If that additional requirement is imposed, provide short sections of the approved types of cables with the approved type of splice and termination kits, and detailed manufacturer's instruction for the proper splicing and termination of the approved cable types. The certification shall be prepared in conformance with paragraph CERTIFICATES OF COMPLIANCE in the SPECIAL CONTRACT REQUIREMENTS, and shall be accompanied by satisfactory proof of the training and experience of persons recommended by the Contractor as cable installers.

1.3.3 Protection Plan

Submit detailed procedures to prevent damage to existing facilities or infrastructures. If damage does occur, the procedures shall address repair and replacement of damaged property at the Contractor's expense.

1.3.4 Prevention of Corrosion

1.3.4.1 Metallic Materials

Protect metallic materials against corrosion as specified. Aluminum shall not be used in contact with earth or concrete.

1.3.4.2 Ferrous Metal Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A123/A123M and ASTM A153/A153M.

1.3.5 As-Built Drawings

Submit as-built drawings that provide current factual information including

deviations from, and amendments to the drawings and changes in the work, concealed and visible, as instructed. The as-built drawings shall show installations with respect to fixed installations not associated with the systems specified herein. Cable and wire shall be accurately identified as to direct-burial or in conduit and shall locate the connection and routing to and away from bases, housings, and boxes.

1.4 PROJECT/SITE CONDITIONS

Items furnished under this section shall be specifically suitable for the following unusual service conditions:

1.4.1 Altitude

Any equipment shall be suitable for operation up to an altitude of 10,000 ft.

1.4.2 Other

Material or equipment to be installed underground; in handholes, manholes, or underground vaults; or in light bases shall be suitable for submerged operation.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide airfield and heliport lighting and visual navigation aids consisting of airfield and heliport lighting, obstruction lighting and marking, runway lights, taxiway lights, visual glide slope indicator, runway end identifier lights, runway distance markers, taxiway signs, and the lighting power supply and control.

a. Submit composite drawings showing coordination of work of one trade with that of other trades and with the structural and architectural elements of the work. Drawings shall be in sufficient detail to show overall dimensions of related items, clearances, and relative locations of work in allotted spaces. Drawings shall indicate where conflicts or clearance problems exist between the various trades.

b. Luminaires fabricated from ferrous metals, unless hot-dip galvanized or of porcelain enamel finish, shall be factory finished with a weather-resistant finish in accordance with paragraphs FACTORY COATING and FINISHING, except exposure shall be 200 hours. Finish color shall be the manufacturer's standard, unless otherwise indicated.

2.2 MATERIALS AND EQUIPMENT

Provide materials and equipment which are the standard product of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Items of the same classification shall be identical including equipment, assemblies, parts, and components.

a. Submit a complete itemized listing of equipment and materials proposed for incorporation into the work. Each itemization shall include an item number, the quantity of items proposed, and the name of the manufacturer.

b. Submit data composed of catalog cuts, brochures, circulars, specifications and product data, and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents.

c. When equipment or materials are specified to conform to the standards or publications and requirements of AASHTO, ANSI, ASTM, AEIC, FM, IEEE, IES, NEMA, NFPA, or UL, or to an FAA, FS, or MS, submit proof that the items furnished under this section conform to the specified requirements. Lighting equipment shall be in accordance with the current version of FAA Advisory Circulator FAA AC 150/5345-53D, Airport Lighting Equipment Certification Program.

d. The label or listing in UL Electrical Constructn or in FM APP GUIDE or the manufacturer's certification or published catalog specification data statement that the items comply with applicable specifications, standards, or publications and with the manufacturer's standards will be acceptable evidence of such compliance.

e. Certificates shall be prepared by the manufacturer when the manufacturer's published data or drawings do not indicate conformance with other requirements of these specifications.

2.3 NAMEPLATES

Each major component of equipment shall have as a minimum the manufacturer's name, address, and catalog or style number on a nameplate securely attached to the item of equipment. Laminated plastic nameplates shall be provided for equipment, controls, and devices to identify function, and where applicable, position. Nameplates shall be 1/8 inch thick laminated cellulose paper base phenolic resin plastic conforming to ASTM D709 sheet type, grade ES-3, white with black center core. Surface shall be a matte finish with square corners. Lettering shall be engraved into the black core. Size of nameplates shall be 1 by 2-1/2 inches minimum with minimum 1/4 inch high normal block lettering. Nameplates provided as indicated. Nameplates shall be fastened to the device with a minimum of two sheet metal screws or two rivets.

2.4 ADDITIONAL REQUIREMENTS

Equipment and materials shall be new unless indicated or specified otherwise. Materials and equipment shall be labeled when approved by Underwriters Laboratories (UL) or Factory Mutual (FM) System. Askarel and insulating liquids containing polychlorinated biphenyls (PCB's) will not be allowed in any equipment. Equipment installed below grade in vaults, manholes, and handholes shall be the submersible type.

2.4.1 Electrical Tape

Electrical tape shall be UL 510 plastic insulating tape.

2.4.2 Conduit, Conduit Fittings, and Boxes

2.4.2.1 Rigid Steel or Intermediate Metal Conduit (IMC) and Fittings

The metal conduit and fittings shall be UL 6 and UL 1242, respectively, coated with a polyvinylchloride (PVC) sheath bonded to the galvanized exterior surface, nominal 40 mils thick, conforming to NEMA RN 1.

2.4.2.2 Flexible Metal Conduit

Flexible metal conduit shall be UL 1, zinc-coated steel. UL 360 liquid-tight flexible metal conduit shall be used in wet locations.

2.4.2.3 Outlet Boxes for Use with Steel Conduit, Rigid or Flexible

These outlet boxes shall be UL 514A, cast metal with gasket closures.

2.4.2.4 Plastic Duct for Concrete Encased Burial

These ducts shall be provided as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.4.2.5 Plastic Conduit for Direct Burial

This plastic conduit shall be PVC conforming to NEMA TC 2 (conduit) and NEMA TC 3 (fittings) Type EPC-80 PVC provided as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.4.2.6 Frangible Couplings and Adapters

These frangible couplings shall be in accordance with FAA 6850.19 and FAA E-2519. Provide upper section of frangible coupling with one of the following:

a. Unthreaded for slip-fitter connections.

b. 2-13/32 inch 16N-1A modified thread for nut and compression ring to secure 2 inch EMT.

c. 2 inch 11-1/2-N.P.T. (tapered) with 7/32 inch nominal wall thickness to accept rigid conduit coupling.

d. Frangible Couplings for specialized applications as approved.

e. Electrical Metallic Tubing UL 797, where indicated for use with frangible couplings and adapters.

2.4.3 Wire and Cable

Conductors shall be copper.

2.4.3.1 Conductor Sizes

Conductor size shall conform to American Wire Gage (AWG). Conductor sizes larger than No. 8 AWG shall be stranded. No. 8 AWG and smaller may be solid or stranded unless otherwise indicated.

2.4.3.2 Low Voltage Wire and Cable

UL 44, Type XHHW.

2.4.3.3 Wire and Cable for Airfield and Heliports

a. Airfield and heliport lighting cable shall be FAA AC 150/5345-7, Type L-824 for crosslinked polyethylene Type C 5000-volt cable. Series airfield and heliport lighting cable shall be unshielded.

b. Cable for pavement slot installation shall be UL 44 Type XHHW, except as indicated otherwise.

c. Counterpoise Wire. No. 4 AWG bare stranded copper, annealed or soft drawn.

d. Control Cable. Multiconductor type FAA AC 150/5345-7, Type C for 120 volt AC control, rated 600 volts, No. 12 AWG, and conforming to the following unless indicated otherwise. Conductors shall be color coded. The cable shall have an overall jacket of heavy-duty neoprene rated for direct burial.

2.4.3.4 Cable Tags

Install cable tags for each cable or wire at duct entrances entering or leaving manholes, handholes, and at each terminal within the lighting vault. Cable tags shall be stainless steel, bronze, lead strap, or copper strip, approximately 1/16 inch thick or hard plastic 1/8 inch thick suitable for immersion in salt water and impervious to petroleum products and shall be of sufficient length for imprinting the legend on one line using raised letters. Cable tags shall be permanently marked or stamped with letters not less than 1/4 inch in height as indicated. Two-color laminated plastic is acceptable. Plastic tags shall be dark colored with markings of light color to provide contrast so that identification can be easily read. Fastening material shall be of a type that will not deteriorate when exposed to water with a high saline content and to petroleum products.

2.4.4 Ground Rods

Ground rods shall be sectional copper-clad steel with diameter adequate to permit driving to full length of the rod, but not less than 3/4 inch in diameter and not more than 10 feet long, unless indicated otherwise.

2.4.5 Lightning Arresters

These lightning arresters shall be for Series Circuits. They shall be rated 25,000 A peak (8/20 microsecond discharge).

2.4.6 Cable Connectors and Splices

Cable connectors in accordance with FAA AC 150/5345-26, Item L-823 shall be used for connections and splices appropriate for the type of cable. Other types of cable connectors and splices shall be of copper alloys for copper conductors. For FAA Type L-824 lighting cable, connectors shall be FAA AC 150/5345-26, Type L-823.

2.4.7 Transformers

2.4.7.1 Encapsulated Isolation Transformers

These transformers shall be FAA AC 150/5345-47, Type L-830. Each transformer shall be provided with rating as shown on the contract drawings.

2.4.8 Light Bases

Light bases shall be FAA AC 150/5345-42 Type L-867 or L-868 as indicated. Steel bases, Class 1, Size B or C shall be provided as indicated or as required to accommodate the fixture or device installed thereon if diameter

is not shown. Base plates, cover plates, and adapter plates shall be provided to accommodate various sizes of fixtures. Bolts shall be stainless steel. Provide non-seize compound for bolts.

2.4.9 Constant Current Regulator

The regulator shall be FAA AC 150/5345-10, Type L-829 with monitoring system and with ratings as indicated. Regulators shall operate on 60 Hz, have internal primary switch included, have input voltage of 480 volts and be controlled by 120-volt external control voltage. Three or Five brightness steps shall be provided as indicated. Monitors shall be provided as indicated.

2.4.10 LED Lamps and Filters

Lamps shall be of size and type indicated, or as required by fixture manufacturer for each lighting fixture required under this contract. Filters shall be of colors as indicated and conforming to the specification for the light concerned or to the standard referenced.

2.4.11 Transformer

The transformer shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.4.12 Lighting Fixtures

Provide lighting fixtures for the airfield and heliport lighting as shown in the contract drawings or as required in other contract documents.

2.5 AIRFIELD AND HELIPORT MARKINGS

The airfield and heliport markings shall be installed as shown on the contract drawings.

2.6 LED RUNWAY END IDENTIFIER LIGHTS (REIL)

The LED REIL fixtures shall meet the requirements of FAA AC 150/5345-51, Type L-849 (L), Style E. The REIL shall include the master and slave fixture, the power supply, remote control by the CCR, frangible mounts, and interconnecting wiring. The REIL units shall flash in unison twice per second. They shall be current driven.

2.7 RUNWAY LIGHTING SYSTEM

LED runway lights include runway edge lights, runway threshold/end lights, runway distance and arresting gear markers, mounting structures, controls, and the associated equipment and interconnecting wiring to provide complete systems as indicated and specified herein. the runway distance and arresting gear markers are existing and are to be re-used. In-pavement light fixtures shall be able to withstand a minimum static single wheel load of 50,000 pounds.

2.7.1 LED Runway Edge Lights

The LED runway edge light fixtures shall meet the requirements of FAA AC 150/5345-46, Type L-862(L), elevated high-intensity Type L-850C(L), semiflush, high-intensity white lights with filters, as required.

2.7.2 LED Runway Threshold and End Lights

The LED threshold lights shall use aviation green filter and the end lights shall use aviation red filters. These lights shall be combined in a single bidirectional fixture with the appropriate color filters if so indicated on the contract drawings. The runway threshold/end light fixtures shall meet the requirements of FAA AC 150/5345-46, Type L-862(L), elevated high-intensity, bidirectional, airfield and heliport lights as indicated.

2.8 LED TAXIWAY LIGHTING SYSTEMS

LED taxiway lighting systems shall include edge lights, guidance signs, and hold position signs. These systems shall also include the associated equipment, power supplies and controls, mounting devices, and interconnecting wiring to provide complete systems as specified.

2.8.1 LED Taxiway Edge Lights

LED taxiway edge lights shall emit aviation blue light provided by filters or globes for both airfields and heliports. The edge lights shall meet the requirements of FAA AC 150/5345-46, Type L-861(L), elevated, Type L-852T(L), semiflush, lights.

2.8.2 Taxiway Guidance Signs

The LED taxiway guidance signs shall meet the requirements of FAA AC 150/5345-44, Type L-858Y(L) for information and Type L-858R(L) for mandatory signs. The size and information on the signs shall be as shown on contract drawings. The power supply to connect to series circuits shall be as indicated.

2.8.3 Hold Position Lights and Signs

The hold positions shall be marked by painted lines and signs as specified or indicated on the contract drawings. Hold position signs shall meet the requirements of FAA AC 150/5345-44, Type L-858R(L), with the size and information as indicated.

2.9 GLIDE SLOPE INDICATOR

The glide slope indicator for airfields shall be the Precision Approach Slope Indicator (PAPI).

2.9.1 LED PAPI

The LED light units for the PAPI shall meet the requirements of FAA AC 150/5345-28, Type L-880(L). The system consists of four light units.

2.10 SERIES CIRCUIT CUTOUTS

Re-use existing series circuit cutouts as available from removed circuits. Provide additional cutouts as needed for new circuits. Cutouts shall be 5 kV, 20 A rated with three positions---operation, maintenance and test/measure. Cutout shall have a grounding connection in addition to the circuit connections. Provide a NEMA 1 enclosure for each cutout as shown on the drawings. In the operational position the 2 CCR output cables shall be connected to the two load cables for that circuit. In the maintenance position the CCR shall be short circuited and grounded and the load circuit shall be short circuited and grounded. In the test/measure position the

CCR shall be short circuited and grounded and the load circuit shall be short circuited and connected to a measurement socket.

2.11 FACTORY COATINGS

Equipment and component items, including but not limited to transformer stations and ferrous metal luminaries not hot-dip galvanized or porcelain enamel finish shall be provided with corrosion-resistant finishes which shall withstand 500 hours of exposure to the salt spray test specified in ASTM B117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1/16 inch from the test mark. The scribed test mark and test evaluation shall be in accordance with ASTM D1654 with a rating of not less than 7 in accordance with TABLE 1, (Procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with zinc rich paint conforming to SSPC Paint 20 in accordance with ASTM A780/A780M.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 GENERAL INSTALLATION REQUIREMENTS

Circuits installed underground shall conform to the requirements of Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, except as required herein. Steel conduits installed underground shall be installed and protected from corrosion in conformance with the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Except as covered herein, excavation, trenching, and backfilling shall conform to the requirements of Section 31 23 00.00 20 EXCAVATION AND FILL. Concrete work shall conform to the requirements of Section 03 30 53 MISCELLANEOUS CAST-IN-PLACE CONCRETE.

3.3 CABLES, GENERAL REQUIREMENTS

The type of installation, size and number of cables shall be as indicated. Conductors larger than No. 8 AWG shall be stranded. Loads shall be divided as evenly as practicable on the various phases of the system. Furnish manufacturer's written recommendations for each type of splice and medium-voltage cable joint and termination, and for fireproofing application methods, approved before any work is done. Medium-voltage cable joints and terminations shall be the standard product of a manufacturer and shall be either of the factory preformed type or of the kit type containing tapes and other required parts. Medium-voltage cable joints shall be made by qualified cable splicers. Compounds and tapes shall be electrical grade suitable for the cable insulation provided and shall use design materials and techniques recommended by the manufacturer. Maximum length of cable pull and cable pulling tensions shall not exceed the cable manufacturer's recommendations.

3.3.1 Duct Line Installation

Install cables in duct lines where indicated. Cable splices in low-voltage cables shall be made in manholes and handholes only, except as otherwise noted. Cable joints in medium-voltage cables shall be made in base cans only. Neutral and ground conductors shall be installed in the same duct

with their associated phase conductors. Counterpoise cable shall be installed direct-burial not less than 6 inches above the uppermost duct containing electrical cable. Electrical metallic tubing shall not be installed underground or enclosed in concrete.

3.3.2 Direct-Burial Installation

3.3.2.1 Trenching for Direct Burial Conduits

Trenches for direct-burial conduits shall be excavated to depths required to provide the minimum necessary cable cover. Bottoms of trenches shall be smooth and free of stones and sharp objects. Where bottoms of trenches comprise materials other than sand or stone-free earth, 3 inch layers of sand or stone-free earth shall be laid first and compacted to approximate densities of surrounding firm soil.

3.3.3 Connection to Buildings

Cables shall be extended into the various buildings as indicated, and shall be properly connected to the first applicable termination point in each building. Interfacing with building interior conduit systems shall be at conduit stubouts terminating 5 feet outside of a building and 2 feet below finished grade as specified and provided under Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. After installation of cables, conduits shall be sealed with caulking compound to prevent entrance of moisture or gases into buildings.

3.4 LOW-VOLTAGE CABLES

Cable shall be rated 600 volts. Other parts of cable systems such as splices and terminations shall be rated at not less than 600 volts. Splices in wires No. 10 AWG and smaller shall be made with an insulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A-486B. Splices in wires No. 8 AWG single conductor cable shall be made with noninsulated, solderless, pressure type connector, conforming to the applicable requirements of UL 486A-486B. They shall then be covered with an insulation and jacket material equivalent to the conductor insulation and jacket. Splices below grade or in wet locations shall be sealed type conforming to ANSI C119.1 or shall be waterproofed by a sealant-filled, thick wall, heat shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.

3.5 DUCT LINES FOR AIRFIELD LIGHTING CABLES

Duct lines shall be non-encased direct-burial, thick-wall type EPC-80.

3.5.1 Requirements

Numbers and sizes of ducts shall be as indicated. Duct lines shall be laid with a minimum slope of 4 inches per 100 feet. Depending on the contour of the finished grade, the high point may be at a terminal, a base can, a handhold, or between manholes or handholes. The minimum manufactured bend radius shall be 18 inches for ducts of less than 3 inches diameter. Both curved and straight sections may be used to form long sweep bends as required, but the maximum curve shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells when duct lines terminate in manholes or handholes. A 5 mil brightly colored plastic tape not less than 3 inches in width and suitably inscribed at not more than 10

feet on centers with a continuous metallic backing and a corrosion-resistant 1 mil metallic foil core to permit easy location of the duct line, shall be placed approximately 12 inches below finished grade levels of such lines.

3.5.2 Treatment

Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. After a duct line is completed, a standard flexible mandrel shall be used for cleaning followed by a brush with stiff bristles. Mandrels shall be at least 12 inches long and shall have diameters 1/4 inch less than the inside diameter of the duct being cleaned. Pneumatic rodding may be used to draw in lead wires. A coupling recommended by the duct manufacturer shall be used when an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

3.5.3 Non-encased Direct-Burial

Top of duct lines shall be less than 18 inches below finished grade. Ducts shall be installed with a minimum of 3 inches of earth around each duct, except that between adjacent electric power and communication ducts, 12 inches of earth is required. Bottoms of trenches shall be graded toward manholes or handholes and shall be smooth and free of stones, soft spots, and sharp objects. Where bottoms of trenches comprise materials other than sand or stone-free earth, 3 inch layers of sand or stone-free earth shall be laid first and compacted to approximate densities of surrounding firm soil before installing ducts in direct-contact tiered fashion. Joints in adjacent tiers of duct shall be vertically staggered at least 6 inches. The first 4 inch layer of backfill cover shall be sand or stone-free earth compacted as previously specified. Duct banks may be held in alignment with earth. However, high-tiered banks shall use a wooden frame or equivalent form to hold ducts in alignment prior to backfilling. Selected earth at duct banks shall be thoroughly tamped in 4 to 6 inch layers.

3.5.4 Installation of Couplings

Joints in each type of duct shall be made up in accordance with the manufacturer's recommendations for the particular type of duct and coupling selected and as approved. In the absence of specific recommendations, various types of duct joint couplings shall be made watertight as specified.

3.5.4.1 Plastic Duct

Duct joints shall be made by brushing a plastic solvent cement on insides of plastic coupling fittings and on outsides of duct ends. Each duct and fitting shall then be slipped together with a quick one-quarter-turn twist to set the joint tightly.

3.6 MANHOLES AND HANDHOLES

The manholes shall be as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Handholes (plaza base cans) shall be as specified in this section.

3.7 CABLE MARKERS

Provide cable markers or tags for each cable at duct entrances entering or leaving base cans and at each termination within the lighting vault. Immediately after cable installation, tags shall be permanently attached to cables and wires so that they cannot be accidentally detached.

3.8 FRANGIBLE REQUIREMENTS

Install frangible supports, couplings, and adapters as indicated or specified.

3.9 ELEVATED AIRFIELD AND HELIPORT LIGHTS

Elevated lights shall be frangibly mounted, not to exceed 14 inches in height. Equipment exceeding 14 inches in height shall be frangibly mounted as indicated.

3.10 SEMIFLUSH AIRFIELD AND HELIPORT LIGHTS

Remove water, debris, and other foreign substances prior to installing semiflush light base and light. Use positioning jigs to hold the light bases and/or lights to ensure correct orientation and leveling until the concrete, adhesive, or sealant can provide permanent support.

3.11 ENCLOSURES IN DRILLED HOLES

3.11.1 Holes for Light Fixtures

Holes shall be bored in existing pavement to the dimensions indicated with a diamond-edged bit to provide a smooth, straight cut. Bottom of hole shall be flat or slightly concave, except that an area at least 1 inch wide around the perimeter shall be flat. Surfaces deeper than the prescribed depth shall be filled with sealant to the level of the flat area and allowed to cure before further placement.

3.12 FIXTURES AND WIRES INSTALLATION

3.12.1 General

Sides and bottom of each light base shall be sandblasted immediately prior to installation. Inside faces of bored hole and bottom and sides of light base shall be covered with a coating of sealant that will completely fill the void between concrete and base. A jig or holding device shall be used when installing each light fixture to ensure positioning to the proper elevation, alignment, level control, and azimuth control. Light fixture shall be oriented with the light beams parallel to the runway or taxiway centerline and facing in the required direction. Outermost edge of fixture shall be level with the surrounding pavement. Surplus sealant or flexible embedding material shall be removed. The holding device shall remain in place until sealant has reached its initial set. Fixture lead wires shall be properly arranged with respect to their connecting position. The wireway entrance into the light recess shall be blocked to retain the sealant material during curing.

3.13 SPLICES FOR AIRFIELD AND HELIPORT LIGHTING CABLE

3.13.1 Connectors

Kit type connectors shall be used to splice 5 kV single-conductor series lighting cables. During installation and prior to covering with earth, mating surfaces of connectors shall be covered until connected and clean when plugged together. At joint where connectors come together, four half-lapped layers of electrical tape over the entire joint shall be provided. Joint shall prevent entrapment of air which might subsequently loosen the joint.

3.14 GROUNDING SYSTEMS

3.14.1 Counterpoise Installation

Counterpoise wire shall be laid for entire length of circuits supplying airfield lighting. Wire shall be in one piece, except where distance exceeds the length usually supplied. Counterpoise shall be installed on top of the envelope of concrete-encased duct and approximately 6 inches above direct burial duct lines. Where trenches or duct lines intersect, counterpoise wires shall be electrically interconnected by exothermic welding or brazing. Counterpoise to earth ground shall be connected at every 500 feet of cable run, at lighting vault, and at feeder connection to light circuit by means of ground rods as specified. Counterpoise shall be installed above the highest duct containing electrical or communications circuits when directionally bored.

3.14.2 Fixture Grounding

Each fixture or group of adjacent fixtures shall be grounded or by driven ground rods or is shown on drawings. Fixtures, steel light bases or grounding bushings on steel conduits shall be connected to an independent ground rod by a No. 6 AWG bare stranded copper wire. Copper wire shall be connected to ground rods by exothermic weld or brazing.

3.15 WIND DIRECTION INDICATORS

Include in the installation a concrete mowing pad constructed on the ground with center at center of the base. The wind cone illumination lights and obstruction lights shall be energized from multiple circuits as shown by the contract drawings or as required otherwise.

3.16 ISOLATION TRANSFORMERS

Transformer lead connections shall conform to FAA AC 150/5345-26. Transformer secondary connectors shall plug directly into a mating connector on the transformer secondary leads. During installation, mating surfaces of connectors shall be covered until connected and clean when plugged together. At joint where connectors come together, four half-lapped layers of electrical tape shall be provided over the entire joint. Joint shall prevent entrapment of air which might subsequently loosen the joint.

3.17 RUNWAY AND TAXIWAY LIGHTING SYSTEMS

3.17.1 Runway and Taxiway Edge Lights

Edge lights shall be elevated type lights except in paved areas where

semiflush lights are required. Threshold and runway end lights shall be elevated type as indicated on the contract drawings. Elevated lights shall be frangibly mounted and each light supplied power through an isolation transformer. The taxiway lights shall be omnidirectional and only require leveling. The runway lights require leveling and alignment of the beams for the correct toe-in of the beams.

3.18 FIELD QUALITY CONTROL

Notify the Contracting Officer five working days prior to each test. Submit performance test reports, upon completion and testing of the installed system, in booklet form showing all field tests performed to adjust each component and all field tests performed to provide compliance with the specified performance criteria. Each test shall indicate the final position of controls. Deficiencies found shall be corrected and tests repeated. Field test reports shall be written, signed and provided as each circuit or installation item is completed. Field tests shall include resistance-to-ground and resistance between conductors, and continuity measurements for each circuit. For each series circuit the input voltage and output current of the constant current regulator at each intensity shall be measured. For multiple circuits the input and output voltage of the transformer for each intensity setting shall be measured. A visual inspection of the lights operation, or of the markings appearance, or of the installation of fixtures or units installed shall be reported.

3.18.1 Operating Test

Test each completed circuit installation for operation. Equipment shall be demonstrated to operate in accordance with the requirements of this Section. One day and one night test shall be conducted for the Contracting Officer.

3.18.2 Distribution Conductors, 600-Volt Class

Test shall verify that no short circuits or accidental grounds exist using an instrument which applies a voltage of approximately 500 volts providing a direct reading in resistance.

3.18.3 Counterpoise System Test and Inspection

Continuity of counterpoise system shall be checked by visual inspection at accessible locations. Continuity of counterpoise system to the vault grounding system shall be tested in manhole closest to the vault.

3.18.4 Progress Testing for Series Lighting Circuits

A megger test shall be conducted on each section of circuit or progressive combinations of sections as they are installed. Each section or progressive combination of sections shall be tested with a megohmmeter providing a voltage of approximately 1000 volts, a direct reading in resistance. Results shall be documented. Faults indicated by these tests shall be eliminated before proceeding with the circuit installation.

3.18.5 Electrical Acceptance Tests

Acceptance tests shall be performed for series and multiple airfield and heliport lighting circuits only on complete lighting circuits. Each series and multiple lighting circuit shall receive a high voltage insulation test.

3.18.5.1 Low-Voltage Continuity Tests

Each series circuit shall be tested for electrical continuity. Faults indicated by this test shall be eliminated before proceeding with the high-voltage insulation resistance test.

3.18.5.2 High-Voltage Insulation Resistance Tests

Each series lighting circuit shall be subjected to a high-voltage insulation resistance test by measurement of the insulation leakage current with a suitable high-voltage test instrument which has a steady, filtered direct current output voltage and limited current. High-voltage tester shall include an accurate voltmeter and microammeter for reading voltage applied to the circuit and resultant insulation leakage current. Voltages shall not exceed test values specified below.

3.18.5.2.1 Test Procedure

Both leads shall be disconnected from regulator output terminals and support so that air gaps of several inches exist between bare conductors and ground. Cable sheaths shall be cleaned and dried for a distance of 1 foot from ends of cables and exposed insulation at ends of cables. Ends of both conductors of the circuit shall be connected together and to high-voltage terminals of test equipment, and test voltage applied as specified in the following tabulation between conductors and ground for a period of 5 minutes.

	Test Voltage, dc	
Series Lighting Circuits	First Test on New Circuits	Test on Existing Circuits
High Intensity Series Lighting Circuits (5,000-Volt Leads, 500- and 200-Watt Transformers)	9000	5000
Medium Intensity Series Lighting Circuits (5,000-Volt Leads, 30/45-Watt Transformers)	6000	3000
600-Volt Circuits	1800	6000
When additions are made to existing circuits, only new sections shall be tested in accordance with "First Test on New Circuits" in this table. To ensure reliable operation, complete circuit shall be tested at reduced voltages indicated.		

3.18.5.2.2 Leakage Current

Insulation leakage current shall be measured and recorded for each circuit after a 1 minute application of the test voltage. If leakage current exceeds values specified below, the circuit shall be sectionalized and retested and the defective parts shall be repaired or replaced. Leakage current limits include allowances for the normal number of connectors and splices for each circuit as follows:

a. Three microamperes for each 1000 feet of cable.

b. Two microamperes for each 200 watt and each 500 watt 5,000-volt series transformer.

c. Two microamperes for each 30/45-Watt 5,000 volt series transformer.

d. If measured value of insulation leakage current exceeds calculated value, the circuit shall be sectionalized and tested as specified for each section. Defective components shall be repaired or replaced until repeated tests indicate an acceptable value of leakage current for the entire circuit.

3.18.6 Constant Current Regulators

Each constant current regulator shall be examined to ensure that porcelain bushings are not cracked, no shipping damage has occurred, internal and external connections are correct, switches and relays operate freely and are not tied or blocked, fuses, if required, are correct, and liquid level of liquid-filled regulators is correct. Relay panel covers shall be removed only for this examination; it is not necessary to open the main tank of liquid-filled regulators. The instructions on the plates attached to the regulators shall be followed. Covers shall be replaced tightly after completing examinations and tests.

3.18.7 Regulator Electrical Tests

Supply voltage and input tap shall correspond. With the loads disconnected, regulator shall be energized and the open circuit protector observed to ensure that it de-energizes the regulator within 3 seconds. After testing circuits for open circuit and ground fault and corrections, if any, and after determining that lamps are serviceable and in place, the loads shall be connected for each circuit or combination of circuits to be energized by the regulator and the voltage and current measured simultaneously for each brightness tap. Voltmeter and ammeter shall have an accuracy of plus or minus 1 percent of meter full scale. Readings shall be recorded during the day and night in order to obtain the average supply voltage. Output current on each brightness tap shall be within plus or minus 2 percent full scale of the nameplate values after making necessary correction in the supply voltage. Late model regulators have automatic supply voltage correction in lieu of input taps, and output current does not change as supply voltage varies. When output current on highest intensity setting deviates from nameplate value by more than 2 percent of meter full scale and the regulator is not overloaded, internal adjustment shall be checked as described on regulator instruction plate. Since adjustment may be rather delicate, a deviation of up to plus or minus 5 percent of meter full scale is allowed for lower intensity settings before attempting to readjust the regulator.

3.19 TRAINING

Submit requirements of training four weeks before training is scheduled to begin. Submit information describing training to be provided, training aids to be used, samples of training materials, and schedules; a list of parts and components for the system by manufacturer's name, part number, nomenclature, and stock level required for maintenance and repair necessary to ensure continued operation with minimal delays; instructions necessary to checkout, troubleshoot, repair, and replace components of the systems, including integrated electrical and mechanical schematics and diagrams and diagnostic techniques necessary to enable operation and troubleshooting after acceptance of the system.

a. Provide training on the proper operation and maintenance procedures for the system. Submit a list of special tools and test equipment required

for maintenance and testing of the products supplied by the Contractor.

b. Submit 6 copies of operation for the equipment furnished. One complete set shall be furnished prior to performance testing and the remainder shall be furnished upon acceptance. Operating manuals shall detail the step-by-step procedures required for system startup, operation, and shutdown. Operating manuals shall include the manufacturer's name, model number, parts list, and brief description of all equipment and their basic operating features.

c. Submit 6 copies of maintenance manuals listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. Maintenance manuals shall include conduit and equipment layout and simplified wiring and control diagrams of the system as installed.

3.20 FINAL OPERATING TESTS

After completion of installations and the above tests, circuits, control equipment, and lights covered by the contract shall be demonstrated to be in acceptable operating condition. Each switch in the control tower lighting panels shall be operated so that each switch position is engaged at least twice. During this process, lights and associated equipment shall be observed to determine that each switch properly controls the corresponding circuit. Telephone or radio communication shall be provided between the operator and the observer. Tests shall be repeated from the alternate control station, from the remote control points, and again from the local control switches on the regulators. Each lighting circuit shall be tested by operating the lamps at maximum brightness for not less than 30 minutes. At the beginning and at the end of this test the correct number of lights shall be observed to be burning at full brightness. One day and one night operating test shall be conducted for the Contracting Officer.

Contractor shall install PAPI systems for 3.0 degree glideslope per manufacturer's instructions. The Government shall flight test the PAPI system. The Contractor shall provide additional adjustments as needed.

3.21 POSTED INSTRUCTIONS

Submit a typed copy of the proposed posted instructions showing wiring, control diagrams, complete layout and operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 27 - COMMUNICATIONS

SECTION 27 13 23.00 40

COMMUNICATIONS OPTICAL BACKBONE CABLING

11/14

PART 1 GENERAL

1.1 REFERENCES
1.2 DEFINITIONS
1.3 ADMINISTRATIVE REQUIREMENTS
1.3.1 Pre-Installation Meetings
1.4 SUBMITTALS
1.5 QUALITY CONTROL
1.5.1 Fiber Optic Cable Installer and Splicer Qualifications
1.5.2 Quality Assurance Plan
1.5.3 Manufacturer's Qualifications
1.5.4 Fiber Optic Factory Test Plan
1.5.5 Fiber Optic Field Tests Plan
1.6 DELIVERY, STORAGE, AND HANDLING

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION
2.1.1 Fiber Optic Cable Design
2.1.1.1 Fiber Optic Media Types
2.1.1.2 Cable Length
2.1.1.3 Construction
2.1.2 Cable Identification Symbol
2.1.3 Temperature Environment
2.1.4 Splice Compatibility Test
2.2 EQUIPMENT
2.2.1 Replacement Cable
2.2.2 Fiber Optic Terminal Cabinets
2.2.3 Fiber Optic Terminations And Connectors
2.2.4 Fiber Optic Pathway System
2.2.4.1 Conduit
2.2.5 FO Media Tags
2.2.6 Buried Warning and Identification Tape
2.3 MATERIALS
2.3.1 Central Core Member
2.3.2 Optical Fibers
2.3.3 Fiber Primary Protective Coating
2.3.4 Optical Fiber Color-Code Coating
2.3.5 Loose Tube Buffering
2.3.6 Colorants
2.3.7 Filling Compound
2.4 TESTS, INSPECTIONS, AND VERIFICATIONS
2.4.1 Factory FO Quality Control
2.4.2 Factory Test Certificates
2.4.2.1 Optical Performance
2.4.2.2 Mechanical Performance

2.4.3 Factory Reel Test

PART 3 EXECUTION

3.1 INSTALLATION
3.1.1 Fiber Splices
3.1.2 Contractor Damage
3.1.3 Underground Cable
3.1.3.1 Securing Cable
3.1.3.2 Bending
3.1.3.3 Pulling
3.1.3.4 Lubricant
3.1.3.5 Damage and Defects
3.1.3.6 Seal
3.1.4 Underground Ducts
3.1.4.1 Connections to Existing Maintenance Holes
3.1.4.2 Connections to Concrete Pads
3.1.4.3 Connections to Existing Ducts
3.1.5 Reconditioning of Surfaces
3.1.5.1 Unpaved Surface Treatment
3.1.5.2 Paving Repairs
3.1.6 Cable Pulling
3.1.6.1 FO Media Tensions
3.1.6.2 Pulling Eyes
3.1.6.3 Media in Maintenance Manholes, Handholes, and Vaults
3.2 FIELD QUALITY CONTROL
3.2.1 Test Requirements
3.2.1.1 Single and Multi-Mode OTDR Test
3.2.1.2 End-to-End Attenuation Tests
3.2.1.3 End-to-End Bandwidth Tests
3.2.2 Field Reel Tests
3.2.2.1 Reel Test Reports
3.2.3 Final Acceptance Tests
3.2.3.1 Test Results
3.3 CLOSEOUT ACTIVITIES

-- End of Section Table of Contents --

SECTION 27 13 23.00 40

COMMUNICATIONS OPTICAL BACKBONE CABLING
11/14

PART 1 GENERAL

1.1 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 D4976	(2012a) Standard Specification for Polyethylene Plastics Molding and Extrusion Materials

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

ANSI/TIA-455-80C	(2003) FOTP-80 - IEC 60793-1-144 Optical fibres Part 1-44: Measurement Methods and Test Procedures - Cut-off Wavelength
TIA/EIA 455-41-A	(1993a; R 2001) FOTP-41 - Compressive Loading Resistance of Fiber Optic Cables

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2012; Errata 1 2012; INT 1-4 2012; Errata 2 2013; INT 5-7 2013; INT 8-10 2014; INT 11 2015) National Electrical Safety Code

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-87-640	(2011) Optical Fiber Outside Plant Communications Cable; 4th Edition

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA RN 1	(2005; R 2013) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2015) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 6 & 8	(2013) Standard for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations
NEMA TC 9	(2004) Standard for Fittings for Polyvinyl

	Chloride (PVC) Plastic Utilities Duct for Underground Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

EIA/TIA 455-165A	(1993) Standard for Mode-Field Diameter Measurement by Near-Field Scanning Technique
TIA-455-104	(1993a; R 2013) Standard for FOTP-104 Fiber Optic Cable Cyclic Flexing Test
TIA-455-175	(2003b) FOTP-175 IEC-60793-1-42: Measurement Methods and Test Procedures - Chromatic Dispersion
TIA-455-33	(2005b; R 2013) Optical Cable Tensile Loading and Bending Test
TIA-455-78-B	(2002) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation
TIA-455-82	(1992b) FOTP-82 Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable
TIA-472D000	(2007b) Fiber Optic Communications Cable for Outside Plant Use
TIA-526-7	(2015a) OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
TIA-568-C.1	(2009; Add 2 2011; Add 1 2012) Commercial Building Telecommunications Cabling Standard
TIA-568-C.3	(2008; Add 1 2011) Optical Fiber Cabling Components Standard
TIA-569	(2015d) Commercial Building Standard for Telecommunications Pathways and Spaces
TIA-590	(1997a) Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant
TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard
TIA/EIA-455	(1998b) Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers,

	Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
TIA/EIA-455-25	(2002c; R 2013) FOTP-25 Impact Testing of Optical Fiber Cables
TIA/EIA-455-81	(2000b) FOTP-81 Compound Flow (Drip) Test for Filled Fiber Optic Cable
TIA/EIA-472DAAA	(1993) Detail Specification for All Dielectric Fiber Optic Communications Cable for Outside Plant Use Containing Class 1a 62.5 Um Core Diameter/125 um Cladding Diameter/250 um Coating Diameter Fiber(s).
TIA/EIA-4750000-C	(1996) Generic Specifications for Fiber Optic Connectors (ANSI)
TIA/EIA-598	(2014d) Optical Fiber Cable Color Coding
TIA/EIA-604-3	(2004b; R 2014) Fiber Optic Connector Intermateability Standard (FOCIS), Type SC and SC-APC, FOCIS-3

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1753F-601	(1994) Specifications for Filled Fiber Optic Cables (PE-90)

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-595	(Rev C; Notice 1) Colors Used in Government Procurement

1.2 DEFINITIONS

References in this section to cable refer to fiber optic ("FO") cable. Fiber optic cable consists of optical fibers, strength member(s), and jacketing. Associated components include optical fiber connectors, terminal bay cabinets, and splice closures as indicated.

1.3 ADMINISTRATIVE REQUIREMENTS

Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to work specified in this section.

1.3.1 Pre-Installation Meetings

Within 30 calendar days after date of award, submit for the approval of the Contracting Officer six (6) copies of outline drawings of all equipment to be furnished under this contract, together with pre-construction and installation drawings and documents. Ensure drawings show the general arrangement and overall dimensions of the cable installation, control centers, space requirements, details of any hidden floor supports or ceiling systems and provisions for conduits for external cables. Submit the following for review and approval:

a. Fiber Optic System Contract Drawings

b. Detailed Shop Drawings

c. Qualifications

d. Quality Assurance Plan

Submit a quality assurance plan for fiber optic cable systems consisting of detailed procedures defining methods to ensure compliance to contract drawings and specifications by drawing control, inspection and procurement records, and test plan showing when and how each system will be tested, material testing, and certification records. Submit test plan to the Technical Representative for approval at least 30 calendar days prior to the start of testing.

Submit manufacturer's product data for the following items. Ensure data includes a complete list of parts, special tools, and supplies with current unit prices and source of supply:.

a. Optical Fibers

b. Fiber Optic Cable Design

c. Fiber Optic Terminal Cabinets

d. Fiber Optic Media Types

e. Fiber Optic Terminations and Connectors

f. Fiber Optic Enclosures

g. Fiber Optic Cable Installer and Splicer Qualifications

h. Manufacturer's Qualifications

i. Fiber Optic System Instructions

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Qualifications; G

Quality Assurance Plan; G

SD-02 Shop Drawings

Fiber Optic System Contract Drawings; G

Detailed Shop Drawings; G

Record (As-Built) Drawings; G

SD-03 Product Data

Optical Fibers; G

Fiber Optic Cable Design; G

Fiber Optic Terminal Cabinets; G

Fiber Optic Media Types; G

Fiber Optic Terminations and Connectors; G

Fiber Optic Enclosures; G

SD-06 Test Reports

Factory Test Certificates; G

Single and Multi-Mode OTDR Test; G

End-to-End Attenuation Tests; G

End-to-End Bandwidth Tests; G

Fiber Optic Factory Test Plan; G

Fiber Optic Field Tests Plan; G

SD-07 Certificates

Fiber Optic Cable Installer and Splicer Qualifications; G

Manufacturer's Qualifications; G

SD-08 Manufacturer's Instructions

Fiber Optic System Instructions; G

1.5 QUALITY CONTROL

1.5.1 Fiber Optic Cable Installer and Splicer Qualifications

Provide technicians installing FO media, splices and performing system tests who are certified and trained in accordance with an approved manufacturers training program, with a minimum of 3 years FO experience in installing equivalent FO systems. Submit data for approval to the Contracting Officer. Submit FO technician qualifications for approval 30 days before splices are to be made on the cable. Certification includes the training, and experience of the individual on specific type and classification of FO media to be provided under this contract.

Contracting officer may require each person who is to perform fiber optic cable splicing to perform a minimum of one acceptable sample splice and termination. Do not incorporate sample splices and terminations in the job.

1.5.2 Quality Assurance Plan

Prepare a quality assurance plan which provides a detailed outline of all testing to be accomplished, addresses whether cladding modes have been stripped prior to testing, source wavelength (peak), spectral width full

width/half maximum (FWHM), mode structure, fiber end preparation, and bandwidth measurements of fiber links both greater and less than 1 kilometer. Quality assurance plan includes, as a minimum, a schedule of when tests will be performed relative to installation milestones, specific test procedure that will be used, a list of test equipment that will be used including manufacturer, model number, range, resolution accuracy and conformance to the specified requirements.

1.5.3 Manufacturer's Qualifications

Ensure FO media manufacturer has a minimum of 3 years experience in the manufacturing, assembly, and factory testing of FO media which comply with RUS Bull 1753F-601. Ensure manufacturer provides a list of customers with 3 years of maintenance logs documenting experience with government customers.

1.5.4 Fiber Optic Factory Test Plan

Prepare and provide to the Government for review a test plan for factory and field tests of the FO media. Provide factory Optical Time Domain Reflectometer(OTDR) test data as part of the test report. Provide a list of factory test equipment. Include a FO link performance test plan. Submit the plan at least 30 days prior to tests for government approval. Refer to TIA-569 for performance measurement criteria. Conduct tests at all operating bandwidths. Provide calculations for optical power budget and bandwidth as required by RUS Bull 1753F-601 using test method TIA-455-78-B or TIA/EIA-455. Submit test plans and reports to the Government for review and approval.

1.5.5 Fiber Optic Field Tests Plan

Prepare and provide technicians and test equipment for field tests of FO media. Conduct OTDR reel tests at the job site prior to installation. Perform OTDR and end to end tests of all installed media. Conduct tests on single mode fiber in accordance with TIA-526-7 for single mode fiber.

1.6 DELIVERY, STORAGE, AND HANDLING

Ship media to job site on factory reels incontinuous lengths. Provide a reel drum radius no smaller than the minimum bend radius recommended by the manufacturer for the media. Wind cable on the reel so that unwinding can be done without kinking the cable. Provide 6 1/2-feet pigtails of cable at each end of the reel readily accessible for testing. Attach a permanent label on each reel showing length, media, identification number, and date of manufacture. Provide water resistant label and ink on the labels. Apply end seals to each end of the media after testing and before terminating to prevent moisture from entering the cable while stored at the job site. Ensure reels are suitable for outside storage conditions when temperature ranges from minus 40 degrees F to plus 150 degrees F, with relative humidity from zero to 100 percent. Store equipment, other than FO media, delivered and placed in storage with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide fiber optic cables for the duct in the cable duct and pullbox system. Provide modifications as design located within the fiber optic

terminal in existing facility buildings.

Provide installation methods and procedures for installing the FO media and pathway system. Include methods and procedures for installing FO media, pathway, and associated hardware. Submit installation procedures and equipment list to the Contracting Officer.

Provide detailed drawings for the fiber optic cable and pathway system. Provide single line schematic details of the fiber optic and pathway media, splices, and associated construction materials. Ensure drawings are in AUTOCAD.DXF or compatible format. Provide Registered Communications Distribution Designer (RCDD) approved drawings of the fiber optic system. Include drawing details of fiber optic terminations in equipment rooms. Show final configuration, including location, fiber pair count, pathway innerduct arrangement, and pathway assignment of outside plant.

2.1.1 Fiber Optic Cable Design

2.1.1.1 Fiber Optic Media Types

Verify FO media meets all performance requirements of TIA-568-C.1, TIA-568-C.3 and the physical requirements of ICEA S-87-640 and TIA/EIA-598.

a. Single Mode Fiber Media

Provide FO single mode media with outer sheath jacket, strength member, ripcords, water blocking material, core tube, and core fibers as installed in a permanent underground pathway system as shown on the construction drawings. Provide media with all glass, dual window, graded index material with a core diameter of 8.7 microns. Coat fiber with a cladding material which is concentric with the core. Ensure fiber cladding diameter is a nominal 125 microns, and media has a transmission window centered at 1300 and 1550 nanometer wavelengths. Attenuation at 1550 nanometers is less than 0.5 dB per kilometer. Verify FO media complies with TIA/EIA-472DAAA,and TIA-758.

2.1.1.2 Cable Length

Ensure cable is manufactured continuous with no factory splices.

2.1.1.3 Construction

a. Number of Fibers Per Tube Per Cable

48-fiber cable is required as follows:

(1) Provide 48-fiber cable containing single mode fibers, with cable core configuration comprised of six loose buffer tubes, each containing 12 fibers. Color code 12 fibers in each loose buffer tube using the first colors of the standard Munsell color code, Blue, Orange, Green, Brown, Slate, White, Red, Black, Yellow, Violet, Rose, and Aqua. Color code loose buffer tubes using the standard Munsell color code, Blue, Orange, Green, and Brown.

b. Inner Jacket

Locate buffer tubes concentrically around the cable central core member and covered with a polyethylene inner jacket. Ensure inner jacket is medium density polyethylene in accordance with ASTM D4976. Fill space between the

buffer tubes and inner jacket with a gel compound to prevent air, moisture, or water intrusion in the inner jacket.

c. Pulling Strength Member

Use a ramid type material as pulling strength members in the cable to provide pulling strength of at least 400 pounds for the cable during installation.

d. Cable Outer Jacket

Apply black medium density, high-molecular weight, polyethylene materials in accordance with ASTM D4976 longitudinally over all the inner jacket and sheathing strength member to form the cable outer jacket. Ensure outer jacket is smooth, concentric, non-nutrient to fungus, and free from holes, splits, blisters, or other imperfections. Overall outside cable diameter cannot exceed 0.75-inch.

2.1.2 Cable Identification Symbol

First of three lines on the ID symbol employ 5 characters.

First and second characters, from left to right, denotes the number of active optical fibers in the cable.

Third character is a slash.

Fourth and fifth characters denote optical transmission windows which the optical fiber can support. These windows are defined herein as follows:

a. Fourth character is an "A" or an "O." The "A" denotes a window at a wavelength of 850 nanometers (nm) with an attenuation of 4 dB/kilometer (km) and a bandwidth of 800 MHz-km. Use an "O" character if these requirements are not met.

b. Fifth character is a "B" or an "O." The "B" denotes a window at a wavelength of 1,300 nanometer (nm) with an attenuation of 1.0 dB/km and a bandwidth of 1,000 MHz-km. Use an "O" character if these requirements are not met.

Two lower lines of the cable ID symbol indicate multi-mode or single mode fibers, the cable number and the fiber count:

Example:

72/OB	Identifies the number of optical fibers (72) and the optical transmission window (OB - See preceding paragraph)
FM05 : 61-120	Identifies Multi-Mode Fiber Cable 05 with MM Fibers 61 through 120.
FS05 : 13-24	Identifies Single Mode Fiber Cable 05 with SM Fibers 13 through 24.

2.1.3 Temperature Environment

Provide fiber optical cable compliant with the mechanical performance requirements herein while used in duct applications where the temperature

varies from minus 17.6 degrees F to 100 F. Ensure optical performance degradation is less than five percent of the optical performance requirements in the temperature range of 4 degrees F to 140 degrees F. Do not damage fiber optical cable in storage where the temperature may vary from 40 degrees F to 149 degrees F.

2.1.4 Splice Compatibility Test

When the material of the optic fiber is different from Cornings' Class Code No. 1528 for single-mode fiber, perform and document the Splice Compatibility Test with Vendor as follows:

a. Select fiber samples from a minimum of 3 different production lots of the fiber type proposed for the job.

b. Fabricate and measure a minimum of 10 fusion splices using fiber from the different production lots and a sample of Corning fiber, Class Code No. 1528, supplied by the Government.

c. Measure fusion splices using an Optical Time Domain Reflectometer (OTDR) operating in the region of 1250 through 1350 nm. Ensure the insertion loss of the fusion splice equals the average of two OTDR measurements, one taken with the OTDR installed on the Corning fiber, and the other with the OTDR installed on the vendor's fiber. Verify Vendor's fiber and the Corning fiber are each a minimum of 1 Km in length throughout the testing.

d. Consider vendor's fiber compatible with the Corning fiber if the maximum splice insertion loss of each of 10 fusion splices tested measures less than 0.2 dB.

   Allow a maximum of three retries on any one splice to obtain a loss of 0.2 dB or less.

Perform these tests under Government supervision.

2.2 EQUIPMENT

2.2.1 Replacement Cable

Provide not less than a 0.5 kilometer reel of each size and type of the manufacturer's furnished cable in addition to cable sections indicated.

Deliver replacement cable reels to the Government as directed by the Contracting Officer.

2.2.2 Fiber Optic Terminal Cabinets

Provide front recess only FOT cabinets. Cabinet's frame consists of vertical and horizontal tubular aluminum extrusions with a minimum wall thickness of .150-inches. Ensure front to rear aluminum extruded corners are at least .125-inches thick, and rear door, top panel, and side panels are a minimum of 18-gage steel. Provide cabinet with 14 gage steel, .281 inches punched panel/chassis mounting rails permitting recessed installation of equipment. Place cable entry and exit holes as indicated. Verify dimensions of cabinet and associated cabinet hardware are as indicated.

Provide gray color cabinet in accordance with FED-STD-595.

2.2.3 Fiber Optic Terminations And Connectors

FO connectors to comply with TIA/EIA-4750000-C and TIA/EIA-604-3.

2.2.4 Fiber Optic Pathway System

Provide an FO pathway system including raceway conduit, duct system, and maintenance handholes as shown on the drawings. Provide pathway materials compliant with TIA-569, and the following commercial standards for construction materials, NEMA RN 1 (PVC), NEMA TC 2 (PVC), NEMA TC 3 (PVC), NEMA TC 6 & 8, and NEMA TC 9.

2.2.4.1 Conduit

Provide conduit as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.2.5 FO Media Tags

Provide stainless steel, 1 5/8-inches in diameter 1/16-inch thick, and circular in shape.

2.2.6 Buried Warning and Identification Tape

Provide color, type and depth of tape as specified in paragraph "Buried Warning and Identification Tape" in Section 31 23 00.00 20 EXCAVATION & FILL. Ensure FO media is marked and protected as required by TIA-590.

2.3 MATERIALS

Verify all materials used within a given cable are compatible with all other materials used in the same cable when such materials come into intimate contact. Ensure all cable components used have no adverse affect on optical transmission or on the mechanical integrity characteristics of the fiber placed in the cable, and all materials used are non-toxic, non-corrosive, and present no dermal hazard.

Minimum required material components applied to fiber optic cable construction are: central core member, color-coded optical fiber, color-coded loose tube buffer with gel-filling, gel-filling around loose tube, inner jacket, pulling strength members, and outer jacket. Variations in sequence and construction structural components will be considered when necessary.

2.3.1 Central Core Member

Include a central core member to serve as a cable core foundation to reduce strain on the fibers but not to serve as a pulling strength member. Ensure material of the central core member is non-metallic.

2.3.2 Optical Fibers

Provide single-mode fiber, within the cable as follows:

a. Provide Single-Mode (SM) fiber of equivalent step index optical glass, with a fiber core diameter of approximately 8.7 micrometer. Cladding diameter is 125 plus or minus 3 micrometer with core cladding offset less than 1 micrometer. Ensure minimum tensile strength of the fiber

after primary protective coating is greater than 50,000 psi.

2.3.3 Fiber Primary Protective Coating

Coat optical fiber with suitable material to preserve the intrinsic high tensile strength of the glass fiber. Ensure outside diameter of the coated optical fiber is 250 (plus or minus 15) micrometer. Provide coating material which is readily removable, mechanically or chemically, without damaging the optical fibers when the removal is desired.

2.3.4 Optical Fiber Color-Code Coating

Coat primary protective coated SM fibers with a color-code coating for individual fiber identification. Maximum outside diameter of color-code coated fiber is less than 300 micrometer.

2.3.5 Loose Tube Buffering

Surround color-code coated fiber(s) with a loose tube buffering for protection from external mechanical and environmental influences. Fill interior of the tube with a suitable gel-fitting compound to prevent water migration. Color code loose tube buffering for the tube identification.

2.3.6 Colorants

Verify color concentrates or inks used to color code the optical fibers and the loose buffer tube are not susceptible to migration and chemical reaction with gel filling compound.

2.3.7 Filling Compound

Ensure inner jacket interior and loose tube buffer cavity contains a gel-type filling compound, of suitable viscosity so that it protects the optical fibers against the ingress of water and/or soluble chemicals, and not flow at the temperature of up to 149 degrees F. Verify gel filling compound is electrically non-conducting, inert gel-type, waterproof compound, non-toxic, with no dermal hazards, and compatible chemically and mechanically with all cable components and associated splice hardware materials to which it may make contact. Ensure gel filling compound is removable, as required, using commercially available products under field-type conditions.

2.4 TESTS, INSPECTIONS, AND VERIFICATIONS

2.4.1 Factory FO Quality Control

Provide conduit factory quality tests of FO media as required by TIA-472D000.

2.4.2 Factory Test Certificates

Provide fiber optical cable complying with the following optical and mechanical test requirements.

2.4.2.1 Optical Performance

a. Single-Mode Fibers in the Cable

Verify optical attenuation of each optical fiber in the cable (reeled) is no greater than 0.5 dB/Km at 1300 plus or minus 50 nm optical spectrum

window. Measure attenuation on completed cable reel length, and normalized linearly to 1 Km. Ensure measurement method is in accordance with TIA-455-78-B, at central wavelength 1300 nm nominal.

Verify pulse dispersion of each optical fiber in the cable (reeled) is no greater than 3.5 picosecond/nm-Km within the emissive region of 1285-1330 nm. Ensure measurement method is in accordance with TIA-455-175.

Verify mode field diameter at 1300 nm optical spectrum window is within 10 plus or minus 1 micrometer. Ensure measurement method is in accordance with EIA/TIA 455-165A at central wavelength 1300 nm nominal. When this requirement is not met, apply the fusion splice compatibility test.

Verify cut-off wavelength for 1300 nm optical spectrum window is within 1200 plus or minus 70 nm. Ensure measurement method is in accordance with ANSI/TIA-455-80C.

2.4.2.2 Mechanical Performance

a. Minimum Bend Radius

Provide cable which withstands bending to a minimum radius of 10 times the cable outer diameter without tensile load applied, and of 20 times the cable outer diameter with maximum tensile load applied (during installation), without damage to cable components or degradation of the optical fiber performance at room temperature.

b. Tensile Strength

Provide fiber optical cable which withstands a pull force of at least 400 pounds to be applied to the pulling strength member during the installation, and a tensile load of at least 66 pounds newtons during operation without incurring any damage or detriment to fiber optical cable and optical performance. Ensure tensile strength test is in accordance with TIA-455-33.

c. Flexing or Bending Cycles

Provide fiber optical cable which withstands at least 20 bending cycles at minimum bend radius without damage to the fiber optic cable components or degrading optical performance. Ensure cyclic flexing test is in accordance with TIA-455-104.

d. Crush Resistance

Provide minimum crush resistance of the fiber optical cable greater than 650 newton/centimeter (cm) without damage to cable components or degrading optical performance. Ensure crush resistance test is in accordance with TIA/EIA 455-41-A.

e. Impact Resistance

Provide fiber optical cable capable of withstanding 20 impacts, at five newton-meters force, without damage to cable components, or degradation of optical performance. Ensure impact resistance test is in accordance with TIA/EIA-455-25.

f. Gel Filling Compound Drip Test

Test optical cable for the ability of the gel filling compound in the interior of the inner jacket and loose tube buffer to resist flow at the temperature range of minus 40 degrees C to 60 degrees C in accordance with TIA/EIA-455-81.

g. Fluid Penetration

Provide optical cable capable of preventing the entry and axial migration of pressurized water when subjected to fluid penetration testing in accordance with TIA-455-82.

2.4.3 Factory Reel Test

Test 100 percent OTDR test of FO media at the factory prior to shipment in accordance with TIA-568-C.1 and TIA-568-C.3. Use TIA-526-7 for single mode fiber measurements. Calibrate OTDR to show anomalies of 0.2 dB minimum. Provide digitized or photographic traces to the Contracting Officer.

PART 3 EXECUTION

3.1 INSTALLATION

Install and test the FO media in accordance with contract drawings, specifications, IEEE C2, NFPA 70, and TIA-590. Provide all necessary power, utility services, technicians, test equipment, calibration equipment as required to perform reel and final acceptance tests of the media. Replace all media which fails the factory or reel tests or final acceptance field tests and re-test at the contractors expense.

3.1.1 Fiber Splices

Splices are not permitted.

3.1.2 Contractor Damage

Promptly repair indicated utility and communications lines or systems damaged during site preparation and construction. When Contractor is advised in writing of the location of a non-indicated line or system, such notice provides that portion of the line or system with "indicated" status in determining liability for damages. In every event, immediately notify the Contracting Officer of damage.

3.1.3 Underground Cable

Provide inner duct assignment of individual cables as indicated. Do not place cables in ducts other than those specified.

Exercise adequate care when handling and storing reels of cable to prevent damage to the cable. Do not install cable with dents, flat spots, or other sheath distortions.

3.1.3.1 Securing Cable

Immediately after cable placement, attach a permanent identification tag as indicated to visible cable sections. Check cables to ensure that the markings are intact.

Support and secure cables and equipment as indicated. Where the specific method of support is not shown, use supports and fasteners to secure cables

and equipment in position. Provide metallic supports and fasteners with a corrosion resistant finish. Rout all cables along the interior sides of pullboxes.

Provide two or more cable hooks per pullbox.

Use clamps and straps as necessary to properly secure the cable.

3.1.3.2 Bending

Use caution when bending cable to avoid kinks or other damage to the sheath. Bend radius is as large as possible with a minimum of 10-inches. Increase minimum radius when necessary to meet cable manufacturer's recommendation. Do not rest cables against any sharp edges.

Pull and splice cable in the manner and at the locations shown.

3.1.3.3 Pulling

Attach pulling lines to both cable ends when cable is destined for bi-directional pull, and fitted with factory-installed pulling eyes. Pull cables not equipped with a pulling eye using a pulling line attached to the cable end by means of a cable grip. Do not use core hitches.

Locate and align cable reels so that the cable is paid out from the top of the reel into the duct or conduit in a long, smooth bend without twisting. Do not pull cable from the bottom of the reel. Use a cable feeder guide of proper dimensions at the mouth to guide the cable into the duct or conduit.

Set up rigging at the pulling end so that the pulling line and cable exit on a line parallel with the duct or conduit to prevent either from rubbing against the edge or mouth. Do not pull cable ends around sheave wheels. When the sheave or pulley cannot be positioned to obtain sufficient cable end slack for proper racking and splicing with the pulling line attached to the end of the cable, a split cable grip may be used to obtain the necessary slack.

3.1.3.4 Lubricant

Use pulling lubricant to minimize pulling tension and prevent sheath damage when pulling cables into ducts and conduits. Apply lubricant to the cable sheath with a lubricator. When pulling has been completed, wipe the exposed cable ends clean of lubricant.

Ensure lubricants are compatible with and intended for use with plastic-sheathed cables. Do not allow soap and grease type lubricants.

Check all equipment and the pulling set to minimize interruptions once pulling begins. Pull cable without stopping until the required amount of the cable has been placed. When the pulling operation is halted before the pull is completed, do not release the tension of the pulling line. When pulling is resumed, overcome the inertia of the cable by increasing the tension in small steps a few seconds apart until the cable is in motion. Feed the cable from the top of the reel by rotating the reel in the feed direction at the rate of pull. Do not strip cable off the reel by pulling.

3.1.3.5 Damage and Defects

Use a tension monitoring device to ensure that the maximum pulling tension

that may be applied to the cable to be pulled into a conduit section is not exceeded. Any damage to the cable due to exceeding the maximum tension will require a new cable furnished by the Contractor.

Carefully inspect cable for sheath defects or other irregularities as it is paid out form the reel. When defects are detected, stop pulling immediately and repair or replace the cable section at the discretion of the Contracting Officer. Maintain a system of communications between pulling and feed locations so that pulling can be stopped instantly, when required.

Hand guide cable through intermediate manholes and into the next duct section when making pull-throughs. Use proper rigging in the intermediate pullboxes to keep the pulling line and cable aligned with the exit duct to prevent the line or cable from rubbing against the edge of the duct. Set up cables in pull-through pullboxes and rack before the cable ends in adjacent pullboxes are set up and racked.

Tie cable ends pulled into pullboxes or terminal locations that are not to be racked or otherwise permanently positioned immediately, in fixed positions to prevent damage to the cables and provide adequate working space.

3.1.3.6 Seal

Seal ducts or innerduct in which cable is placed with urethane foam duct seal. Insert this material between the cable and the duct or innerduct of which it is in, between the innerduct and the duct, and in all unused innerduct, in order to prevent damage to the cable sheath and to prevent the entrance of dirt or water into the pullboxes.

Provide cables in continuous lengths as required to accomplish the required installation without splices from termination to termination, except where field splices are specifically shown.

3.1.4 Underground Ducts

Construct underground duct as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Encase in concrete any ducts under roads, paved areas, or railroad tracks.

3.1.4.1 Connections to Existing Maintenance Holes

For duct line connections to existing structures, break the structure wall out to the dimensions required and preserve the steel in the structure wall. Cut the steel and the duct line envelope.

3.1.4.2 Connections to Concrete Pads

For duct line connections to concrete pads, break an opening in the pad out to the dimensions required and preserve the steel in the pad. Cut the steel and extend it out to tie into the reinforcing of the duct line envelope. Chip out the opening in the pad to form a key for the duct line envelope.

3.1.4.3 Connections to Existing Ducts

Where connections to existing duct lines are indicated, excavate the lines to the maximum depth required. Cut off lines and remove loose concrete

from the conduits before new concrete encased ducts are installed. Provide reinforced concrete collar, poured monolithically with the new duct line to take the shear at the joint of the duct lines.

3.1.5 Reconditioning of Surfaces

3.1.5.1 Unpaved Surface Treatment

Restore unpaved surfaces disturbed during the installation of duct or direct burial cable to their original elevation and condition. Carefully preserve existing sod and topsoil and replace after the back-filling is completed. Replace damaged sod with sod of quality equal to that removed. Where the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding.

3.1.5.2 Paving Repairs

a. Where trenches, pits, or other excavations are made in existing roadways and in other areas of pavement where surface treatment of any kind exists, restore such surface treatment or pavement to the same thickness and to the same kind as previously existed. Ensure surface treatment or pavement matches and ties into the adjacent and surrounding existing surfaces.

3.1.6 Cable Pulling

Test duct lines with a mandrel and swab out to remove foreign material before the pulling of FO media. Avoid damage to cables in setting up pulling apparatus or in placing tools or hardware. Do not step on media when entering or leaving the maintenance holes. Do not place media in ducts other than those shown without prior written approval of the Contracting Officer. Roll cable reels in the direction indicated by the arrows painted on the reel flanges. Set up media reels on the same side of the maintenance hole as the pathway section in which the media is to be placed. Level the reel and bring into proper alignment with the pathway section so that the media pays off from the top of the reel in a long smooth bend into the duct without twisting. Do not, under any circumstances roll the media off from the bottom of the reel. Check the equipment set up prior to beginning the media cable pulling to avoid an interruption once pulling has started. Use a cable feeder guide of suitable dimensions between media reel and face of duct to protect media and guide cable into the duct as it is rolled off the reel. As media is rolled off the reel, lubricate and inspect media for sheath defects. When defects are noticed, stop pulling operations and notify the Contracting Officer to determine required corrective action. Stop media pulling if reel binds or does not roll off freely. Rectify cause of binding before resuming pulling operations. Provide media lubricants recommended by the cable manufacturer. Provide 3.3-feet of spare media in all manholes and enclosures for final termination and testing.

3.1.6.1 FO Media Tensions

Install FO media as shown on construction drawings. Provide devices to monitor media tension during installation. Do not exceed manufacturers recommended maximum FO tensions and bending radii during installation.

3.1.6.2 Pulling Eyes

Equip media 1-1/4-inches in diameter and larger with cable manufacturer's factory installed pulling-in eyes. Provide media with diameter smaller than 1-1/4-inches with heat shrinkable type end caps or seals on cable ends when using cable pulling grips. Do not beat rings to prevent grip from slipping into the cable sheath. Use a swivel grip of 3/4-inch links between pulling-in eyes or grips and pulling strand.

3.1.6.3 Media in Maintenance Manholes, Handholes, and Vaults

Do not install media utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances. Support media on brackets and cable insulators at a maximum of 4-feet. In existing maintenance manholes, handholes, and vaults where new ducts are to be terminated, or where new media are to be installed, modify the existing installation of media, cable supports, and grounding as required with cables arranged and supported as specified for new media.

3.2 FIELD QUALITY CONTROL

3.2.1 Test Requirements

Ensure test equipment used for verifying installation testing is calibrated by a certified testing company within 3 weeks of use.

3.2.1.1 Single and Multi-Mode OTDR Test

Ensure the Optical Time Domain Reflectometer (OTDR) conforms to the following minimum requirements:

a. Operating wavelengths: 1,300 plus or minus 20 nanometers

b. Attenuation Range (one way): minimum 15 dB at 1,300 nm

c. Attenuation Resolution: 0.01 dB

d. Accuracy: plus 0.5 dB

Use OTDRs with digital readout capability and a means of providing a permanent record in the form of a strip chart.

3.2.1.2 End-to-End Attenuation Tests

An attenuation measurement test set consists of an optical power meter and an optical power source. Provide attenuation measurement test set in accordance with the applicable National Bureau of Standards (NBS) standards for a stable optical source. Meter may be analog or digital. Include end-to-end attenuation test reading on the test reference loss. Ensure measurement test set conforms to the following minimum requirements:

a. Operating wavelengths: 1,300 plus or minus 10 nanometers

b. Attenuation Range: at least 30 dB at 1,300 nm

c. Attenuation Resolution: 0.01 dB

d. Accuracy: The accuracy of the attenuation measurement test set is plus

or minus 5 percent.

Ensure optical source is capable of coupling sufficient power into the fiber so that the light received at the meter is within the meter delectability limits.

3.2.1.3 End-to-End Bandwidth Tests

Ensure bandwidth test conforms to the following minimum requirements:

a. Operating wavelengths: 1,300 plus or minus 10 nanometers

b. Bandwidth range: minimum 1000 megahertz

c. Bandwidth Resolution: 1 megahertz

d. Accuracy: plus or minus 0.5 megahertz, Measurement Method: Swept Frequency

As a minimum, test each fiber cable before and after installation for any faults or attenuations using an Optical Time Domain Reflectometer (OTDR). Conduct end-to-end attenuation tests after complete installation.

Clearly state all test equipment, test procedures, and testing techniques in the quality assurance plan. Conduct tests in accordance with the approved Quality Assurance Plan. Ensure all field tests are witnessed by the Contracting Officer. Give Contracting Officer at least 20 calendar days notice prior to performing each test.

Provide each test sheet with a sign-off blank for both Contractor and the Contracting Officer. Deliver copies of the completed test forms and test results as indicated.

Record sequential cable markings along the cable on the sequential cable form, prior to and after each end of splice point,and submit for approval.

Submit test results on all installed fiber cabling before and after each pre-connectorized cable assembly splice is completed.

Maintain an accurate test record during all field tests.

3.2.2 Field Reel Tests

Perform the following tests on FO media at the job site before it is removed from the cable reel. For cables with factory installed pulling eyes, perform these tests at the factory and submit certified test results with the media. Perform OTDR tests with media on reels and compare factory and field test data.

3.2.2.1 Reel Test Reports

Provide results of reel tests to the Contracting Officer within 5 working days before installation is to commence. Verify results indicate reel number of the media, manufacturer, type and number of fiber tested, and recorded readings in the report. When reel tests indicate that the media does not comply with factory reel test reports remove the media from the job site and replace with compliant media.

3.2.3 Final Acceptance Tests

Perform end-to-end tests including power meter light source and OTDR tests. Perform OTDR measurements as required by TIA-568-C.1 and TIA-568-C.3. Test single mode fiber in accordance with TIA-526-7 (Optical Power Loss).

3.2.3.1 Test Results

Provide results of final acceptance tests (attenuation tests, OTDR traces, etc.), to the Contracting Officer within 5 working days after completion of tests.

3.3 CLOSEOUT ACTIVITIES

Submit 3 copies of the Record (As-Built) Drawings to the Contracting Officer.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 31 - EARTHWORK

SECTION 31 05 19

GEOTEXTILE

08/08

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 DELIVERY, STORAGE, AND HANDLING
1.3.1 Delivery
1.3.2 Storage
1.3.3 Handling

PART 2 PRODUCTS

2.1 RAW MATERIALS
2.1.1 Geotextile
2.2 MANUFACTURING QUALITY CONTROL SAMPLING AND TESTING

PART 3 EXECUTION

3.1 QUALITY ASSURANCE SAMPLES AND TESTS
3.1.1 Quality Assurance Samples
3.1.2 Quality Assurance Tests
3.2 INSTALLATION
3.2.1 Subgrade Preparation
3.2.2 Placement
3.3 SEAMS
3.3.1 Overlap Seams
3.4 PROTECTION
3.5 REPAIRS
3.6 PENETRATIONS
3.7 COVERING

-- End of Section Table of Contents --

SECTION 31 05 19

GEOTEXTILE
08/08

PART 1 GENERAL

1.1 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 D4354	(2012) Sampling of Geosynthetics for Testing
ASTM D4355/D4355M	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491/D4491M	(2015) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533/D4533M	(2015) Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D4632/D4632M	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2012) Determining Apparent Opening Size of a Geotextile
ASTM D4759	(2011) Determining the Specification Conformance of Geosynthetics
ASTM D4873	(2015) Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D6241	(2014) Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Manufacturing Quality Control Sampling and Testing

SD-04 Samples

Quality Assurance Samples and Tests

SD-07 Certificates

Geotextile

1.3 DELIVERY, STORAGE, AND HANDLING

Deliver, store, and handle geotextile in accordance with ASTM D4873.

1.3.1 Delivery

Notify the Contracting Officer a minimum of 24 hours prior to delivery and unloading of geotextile rolls packaged in an opaque, waterproof, protective plastic wrapping. The plastic wrapping shall not be removed until deployment. If quality assurance samples are collected, immediately rewrap rolls with the plastic wrapping. Geotextile or plastic wrapping damaged during storage or handling shall be repaired or replaced, as directed. Label each roll with the manufacturer's name, geotextile type, roll number, roll dimensions (length, width, gross weight), and date manufactured.

1.3.2 Storage

Protect rolls of geotextile from construction equipment, chemicals, sparks and flames, temperatures in excess of 160 degrees F, or any other environmental condition that may damage the physical properties of the geotextile. To protect geotextile from becoming saturated, either elevate rolls off the ground or place them on a sacrificial sheet of plastic in an area where water will not accumulate.

1.3.3 Handling

Handle and unload geotextile rolls with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Rolls shall not be dragged along the ground, lifted by one end, or dropped to the ground.

PART 2 PRODUCTS

2.1 RAW MATERIALS

A minimum of 7 days prior to scheduled use, submit manufacturer's certificate of compliance stating that the geotextile meets the requirements of this section. For needle punched geotextiles, the manufacturer shall also certify that the geotextile has been continuously inspected using permanent on-line full-width metal detectors and does not contain any needles which could damage other geosynthetic layers. The certificate of compliance shall be attested to by a person having legal authority to bind the geotextile manufacturer.

2.1.1 Geotextile

Provide geotextile that is a woven pervious sheet of polymeric material consisting of long-chain synthetic polymers composed of at least 95 percent by weight polyolefins, polyesters, or polyamides. The use of woven slit film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character) will not be allowed. Add stabilizers and/or inhibitors to the base polymer, as needed, to make the filaments resistant to deterioration

by ultraviolet light, oxidation, and heat exposure. Regrind material, which consists of edge trimmings and other scraps that have never reached the consumer, may be used to produce the geotextile. Post-consumer recycled material shall not be used. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. Geotextiles shall meet the requirements specified in Table 1. Where applicable, Table 1 property values represent minimum average roll values (MARV) in the weakest principal direction. Values for AOS represent maximum average roll values.

TABLE 1
MINIMUM PHYSICAL REQUIREMENTS FOR DRAINAGE GEOTEXTILE

PROPERTY	UNITS	ACCEPTABLE VALUES	TEST METHOD
GRAB STRENGTH	LBS	248	ASTM D4632/D4632M
SEAM STRENGTH	LBS	223	ASTM D4632/D4632M
PUNCTURE	LBS	495	ASTM D6241
TRAPEZOID TEAR	LBS	57	ASTM D4533/D4533M
APPARENT OPENING SIZE	U.S. SIEVE	40	ASTM D4751
PERMITTIVITY	SEC -1	0.5	ASTM D4491/D4491M
ULTRAVIOLET DEGRADATION	PERCENT	50 AT 500 HRS	ASTM D4355/D4355M

2.2 MANUFACTURING QUALITY CONTROL SAMPLING AND TESTING

The Manufacturer is responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the specification. A minimum of 7 days prior to scheduled use, submit manufacturer's quality control manual. Documentation describing the quality control program shall be made available upon request. Perform manufacturing quality control sampling and testing in accordance with the manufacturer's approved quality control manual. As a minimum, geotextiles shall be randomly sampled for testing in accordance with ASTM D4354, Procedure A. Acceptance of geotextile shall be in accordance with ASTM D4759. Tests not meeting the specified requirements will result in the rejection of applicable rolls.

PART 3 EXECUTION

3.1 QUALITY ASSURANCE SAMPLES AND TESTS

3.1.1 Quality Assurance Samples

Provide assistance to the Contracting Officer in the collection of quality

assurance samples for quality assurance testing; assign 7 days in the schedule to allow for testing. Collect samples upon delivery to the site at the request of the Contracting Officer. Identify samples with a waterproof marker by manufacturer's name, product identification, lot number, roll number, and machine direction. The date and a unique sample number shall also be noted on the sample. Discard the outer layer of the geotextile roll prior to sampling a roll. Samples shall then be collected by cutting the full-width of the geotextile sheet a minimum of 3 feet long in the machine direction. Rolls which are sampled shall be immediately resealed in their protective covering.

3.1.2 Quality Assurance Tests

Provide quality assurance samples to an Independent Laboratory. Samples will be tested to verify that geotextile meets the requirements specified in Table 1. Test method ASTM D4355/D4355M shall not be performed on the collected samples. Geotextile product acceptance shall be based on ASTM D4759. Tests not meeting the specified requirements will result in the rejection of applicable rolls.

3.2 INSTALLATION

3.2.1 Subgrade Preparation

The surface underlying the geotextile shall be smooth and free of ruts or protrusions which could damage the geotextile. Subgrade materials and compaction requirements shall be in accordance with Section 31 23 00.00 20 EXCAVATION & FILL.

3.2.2 Placement

Notify the Contracting Officer a minimum of 24 hours prior to installation of geotextile. Geotextile rolls which are damaged or contain imperfections shall be repaired or replaced as directed. The geotextile shall be laid flat and smooth so that it is in direct contact with the subgrade. The geotextile shall also be free of tensile stresses, folds, and wrinkles. On slopes steeper than 10 horizontal on 1 vertical, lay the geotextile with the machine direction of the fabric parallel to the slope direction.

3.3 SEAMS

3.3.1 Overlap Seams

Continuously overlap geotextile panels in accordance with manufacturer recommendation and a minimum of 12 inches at all longitudinal and transverse joints. Where seams must be oriented across the slope, lap the upper panel over the lower panel. If approved, sewn seams may be used instead of overlapped seams.

3.4 PROTECTION

Protect the geotextile during installation from clogging, tears, and other damage. Damaged geotextile shall be repaired or replaced as directed. Use adequate ballast (e.g. sand bags) to prevent uplift by wind. The geotextile shall not be left uncovered for more than 7 days after installation.

3.5 REPAIRS

Repair torn or damaged geotextile. Clogged areas of geotextile shall be removed. Perform repairs by placing a patch of the same type of geotextile over the damaged area. The patch shall extend a minimum of 12 inches beyond the edge of the damaged area. Patches shall be continuously fastened using approved methods. The machine direction of the patch shall be aligned with the machine direction of the geotextile being repaired. Remove and replace geotextile rolls which cannot be repaired. Repairs shall be performed at no additional cost to the Government

3.6 PENETRATIONS

Construct engineered penetrations of the geotextile by methods recommended by the geotextile manufacturer.

3.7 COVERING

Do not cover geotextile prior to inspection and approval by the Contracting Officer. Place cover soil in a manner that prevents soil from entering the geotextile overlap zone, prevents tensile stress from being mobilized in the geotextile, and prevents wrinkles from folding over onto themselves. On side slopes, soil backfill shall be placed from the bottom of the slope upward. Cover soil shall not be dropped onto the geotextile from a height greater than 3 feet. No equipment shall be operated directly on top of the geotextile without approval of the Contracting Officer. Use equipment with ground pressures less than 7 psi to place the first lift over the geotextile. A minimum of 12 inches of soil shall be maintained between full-scale construction equipment and the geotextile. Cover soil material type, compaction, and testing requirements are described in Section 31 23 00.00 20 EXCAVATION & FILL. Equipment placing cover soil shall not stop abruptly, make sharp turns, spin their wheels, or travel at speeds exceeding 5 mph.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 33 - UTILITIES

SECTION 33 05 23.13

UTILITY HORIZONTAL DIRECTIONAL DRILLING

11/13

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 COMMENCEMENT, DELIVERY, STORAGE, AND HANDLING OF MATERIALS
1.4 QUALITY ASSURANCE
1.4.1 Qualifications
1.4.2 Safety

PART 2 PRODUCTS

2.1 EQUIPMENT
2.1.1 Drill Rod
2.1.2 Pipe
2.1.3 High Density Polyethylene Conduits for Airfield Lighting Circuits
2.1.4 Bore Spacers for Conduits Inside Carrier Pipe
2.2 MATERIALS
2.2.1 Drilling Fluids

PART 3 EXECUTION

3.1 INSTALLATION
3.1.1 Drill Set-Up
3.1.2 Drill Entrance and Exit Pits
3.1.3 Drill Entrance and Exit Angle
3.1.4 Pilot Hole
3.1.5 Guidance Systems
3.1.6 Reaming
3.1.7 Pull Back
3.2 FIELD QUALITY CONTROL
3.3 CLOSEOUT ACTIVITIES

-- End of Section Table of Contents --

SECTION 33 05 23.13

UTILITY HORIZONTAL DIRECTIONAL DRILLING
11/13

PART 1 GENERAL

1.1 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 ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 180	(2015) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

ASTM INTERNATIONAL (ASTM)

ASTM D2447	(2003) Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter
ASTM F2160	(2010) Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)

FLORIDA DEPARTMENT OF TRANSPORTATION (FDOT)

FLDOT	(2016) Section 121 Flowable Fill - Standard Specifications for Road and Bridge Construction

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA TC 7	(2013) Standard for Smooth-Wall Coilable Electrical Polyethylene Conduit

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1926.652	Safety and Health Regulations for Construction; Subpart P, Excavations; Requirements for Protective Systems

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Statement of Qualifications and Records; G

SD-02 Shop Drawings

Record Drawings; G

SD-03 Product Data

Fused High Density Polyethylene Pipe or Fused PVC Carrier Pipe; G

Drilling Fluids; G

Additives; G

Mixtures; G

Hdpe Inner Conduits

Spacers For Inner Conduits

Flexible Fill (Controlled Low Strength Material) Concrete Mix

SD-05 Design Data

Material Safety Data Sheets; G

SD-06 Test Reports

Soil Test Data; G

SD-07 Certificates

Drill Rod; G

SD-11 Closeout Submittals

Complete Work Logs of Guided Directional Drill Operations; G

1.3 COMMENCEMENT, DELIVERY, STORAGE, AND HANDLING OF MATERIALS

Prior to commencement of the work, submit the following to the Engineer of Record for review and approval:

a. Fused High Density Polyethylene Pipe or Fused PVC Carrier Pipe

b. HDPE Inner Conduits 2-inch

c. Spacers for Inner Conduits

d. Flexible Fill (Controlled Low Strength Material) Concrete Mix

e. Material Safety Data Sheets

f. Statement of Qualifications and Records

g. Soil Test Data

Provide written documentation of conformance with AASHTO T 180. Submit a

complete list of all drilling fluids, additives, and mixtures to be used along with Material Safety Data Sheets.

Inspect materials delivered to the site for damage. All materials found during inspection or during the progress of work to have cracks, flaws, surface abrasions, or other defects will be rejected. Remove defective materials from the job site.

1.4 QUALITY ASSURANCE

1.4.1 Qualifications

Ensure that Contractor and his field supervisor assigned to this project are experienced in work of this nature and have successfully completed similar projects of similar length, pipe type, pipe size, and soil type using directional drilling in the last three (3) years. As part of the bid submission, submit a description of such project(s) which include, at a minimum, a listing of the location(s), date of project(s), owner, pipe type, size installed, length of installation, type, and manufacturer of equipment used, and other information relevant to the successful completion of the project.

1.4.2 Safety

Include in directional drilling equipment machine safety requirements a common grounding system to prevent electrical shock in the event of underground electrical cable strike. Ensure the grounding system connects all pieces of interconnecting machinery; the drill, mud mixing system, drill power unit, drill rod trailer, operators booth, worker grounding mats, and any other interconnected equipment to a common ground. Equip the drill with an "electrical strike" audible and visual warning system that notifies the system operators of an electrical strike.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Drill Rod

Select the appropriate drill rod to be used. Submit certified statement that the drill rod has been inspected and is in satisfactory condition for its intended use.

2.1.2 Pipe

Carrier pipe shall be fused HDPE or fused PVC pipes to contain 2-inch conduits for airfield lighting cables. Carrier pipes shall have a dimension ratio of 11 maximum. The requirements of FLDOT Specifications Section 121 Flowable Fill.

2.1.3 High Density Polyethylene Conduits for Airfield Lighting Circuits

Provide 2-inch Schedule 80 solid smooth wall HDPE conduits in the carrier pipe for the airfield lighting circuits. Conduits shall meet ASTM D2447/ ASTM F2160/NEMA TC 7 and be ETL or UL listed to be compliant NEC.

Articles 300 and 353. Provide minimum 1130 pound strength polyester pull tapes in the spare conduits.

2.1.4 Bore Spacers for Conduits Inside Carrier Pipe

Provide HDPE spacers with polyolefin wheel assemblies for supporting the cable conduits inside the carrier pipe. The spacers should be suitable for the quantity of 2-inch HDPE conduits shown on the drawings. In addition, each spacer unit shall have an opening for a withdrawable grout injection pipe. The pipe shall be used for conveying the cellular concrete grout from the ends of the carrier pipe to the center or opposite end. Spacers should have openings for minimum two No. 4 bare copper cables. Spacers shall be provided on 5 foot centers. At each spacer provide a polypropylene strapping around the conduits to prevent the spacers from slipping along the conduits. The grout shall meet the requirements of FLDOT specifications Section 121 Flowable Fill.

2.2 MATERIALS

2.2.1 Drilling Fluids

Disposal of fluids off-base is the responsibility of the Contractor. Dispose of fluids in a manner that is in compliance with all permits and applicable Federal, State, and local regulations.

Use a high quality bentonite drilling fluid to ensure hole stability, cuttings transport, bit and electronics cooling, and hole lubrication to reduce drag on the drill pipe and the product pipe. Use only fluid with a composition which complies with all Federal, State, and local environmental regulations.

Mix the bentonite drilling fluid with potable water (of proper pH) to ensure no contamination is introduced into the soil during the drilling, reaming, or pipe installation process. The Contractor is responsible for any required pH adjustments.

Disposal of the drilling fluids is the responsibility of the Contractor. Conduct disposal in compliance with all relative environmental regulations, right-of-way and work space agreements, and permit requirements.

Collect drilling fluid returns in the entrance pit, exit pit, or spoils recovery pit. Immediately clean up any drilling fluid spills or overflows from these pits.

PART 3 EXECUTION

3.1 INSTALLATION

Ensure all utilities are located and clearly marked prior to start of excavation or drilling.

3.1.1 Drill Set-Up

Design and construct the drill entrance and exit pits.

3.1.2 Drill Entrance and Exit Pits

Drill entrance and exit pits are required. Maintain at minimum size to allow only the minimum amount of drilling fluid storage prior to transfer to mud recycling or processing system or removal from the site.

Do not allow drilling mud to flow freely on the site or around the entrance

or exit pits. Remove spilled mud and restore ground to original condition. Provide shore pits in compliance with OSHA Standards, 29 CFR 1926.652.

When drilling near wetlands or water courses, provide secondary containment to prevent drilling fluids from entering the wetlands, and secure written approval of secondary containment plan from the Contracting Officer.

3.1.3 Drill Entrance and Exit Angle

Ensure entrance and exit angles and elevation profile maintains adequate cover to reduce risk of drilling fluid breakouts and ground exit occurs as specified herein. Ensure that entrance and exit angles generate pullback forces that do not exceed 5 percent strain on the pipe.

3.1.4 Pilot Hole

The type and size of the pilot string cutting head and the diameter of the drill pipe is at the Contractor's discretion.

Drill the pilot hole along the path shown on the plan and profile drawings. Pilot hole tolerances are as follows:

a. Vertical Tolerance: Provide minimum cover below channel bottom as specified on the plans. Pilot hole may go deeper if necessary to prevent breakout.

b. Horizontal Tolerance: Plus/minus - 60-inches from the centerline of the product pipe.

c. Curve Radius: No horizontal curve is acceptable with a radius less than 1,000-feet.

d. Entry Point Location: Make pilot hole entry point within plus/minus - 60-inches of the location shown on the drawings or as directed by the Contracting Officer in the field.

e. Exit Point Location: Make the exit point location within plus/minus - 60-inches of the location shown on the drawings or as directed by the Contracting Officer in the field.

f. Mandatory pipeline cover requirements are as shown on the drawings or as specified.

3.1.5 Guidance Systems

Walkover guidance systems are not acceptable for this project; use a magnetic survey tool locator installed behind the pilot string cutting head and an electric grid (tru-tracker) system for this project.

3.1.6 Reaming

Conduct reaming operations at the Contractor's discretion. Determine the type of back reamer to be utilized by the type of subsurface soil conditions that are encountered during the pilot hole drilling operation. The reamer type is at the Contractor's discretion.

3.1.7 Pull Back

Fully assemble the entire pipeline to be installed via direction drill prior to commencement of pull back operations.

Support the pipeline during pullback operations in a manner to enable it to move freely and prevent damage. Install the pipeline in one continuous pull.

Minimize torsion stress by using a swivel to connect the pull section to the reaming assembly.

Maximum allowable tensile force imposed on the pull section is not to exceed 90 percent of the pipe manufacturer's safe pull (or tensile) strength. If the pull section is made up of multiple pipe size or materials, the lowest safe pull strength value governs and the maximum allowable tensile force is not to exceed 90 percent of this value.

Minimize external pressure during installation of the pullback section in the reamed hole. Replace damaged pipe resulting from external pressure at no cost to the Government. Buoyancy modification is at the discretion of the Contractor.

3.2 FIELD QUALITY CONTROL

Maintain drilling logs that accurately provide drill bit location (both horizontally and vertically) at least every 2-inches along the drill path. In addition, keep logs that record, as a minimum the following, every 15 minutes throughout each drill pass, back ream pass, or pipe installation pass:

a. Drilling Fluid Pressure

b. Drilling Fluid Flow Rate

c. Drill Thrust Pressure

d. Drill Pullback Pressure

e. Drill Head Torque

Make all instrumentation, readings, and logs available to the Contracting Officer at all times during operation.

3.3 CLOSEOUT ACTIVITIES

Immediately upon completion of work, remove all rubbish and debris from the job site. Remove all construction equipment and implements of service leaving the entire area involved in a neat condition acceptable of the Contracting Officer.

Immediately clean "blow holes" or "breakouts" of drilling fluid to the surface and return the surface area to its original condition. Dispose of all drilling fluids, soils, and separated materials in compliance with Federal, State, and local environmental regulations.

Submit an electronic copy and three hard copies of the record drawings to the Contracting Officer within five days after completing the pull back. Include in the record drawings a plan, profile, and all information

recorded during the progress of the work. Clearly tie the record drawings to the project's survey control. Maintain and submit upon completion signed complete work logs of guided directional drill operations.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 33 - UTILITIES

SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION

02/15

PART 1 GENERAL

1.1 REFERENCES
1.2 DEFINITIONS
1.3 SUBMITTALS
1.4 QUALITY ASSURANCE
1.4.1 Certificate of Competency for Cable Splicer/Terminator
1.4.2 Cable Installer Qualifications
1.4.3 Directional Boring Certificate of Conformance
1.4.4 Regulatory Requirements
1.4.5 Standard Products
1.4.5.1 Alternative Qualifications
1.4.5.2 Material and Equipment Manufacturing Date

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS
2.1.1 Rigid Metal Conduit
2.1.2 Plastic Conduit for Direct Burial and Riser Applications
2.1.3 Plastic Duct for Concrete Encasement
2.1.4 High Density Polyethylene (HDPE) Electrical Conduit for Directional Boring
2.1.5 Duct Sealant
2.1.6 Fittings
2.1.6.1 Metal Fittings
2.1.6.2 PVC Conduit Fittings
2.1.6.3 PVC Duct Fittings
2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES
2.2.1 Conductor Types
2.2.2 Conductor Material
2.2.3 Jackets
2.2.4 In Duct
2.2.5 Cable Marking
2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS
2.4 LOW VOLTAGE SPLICES
2.4.1 Heat Shrinkable Splice
2.5 MEDIUM VOLTAGE CABLE
2.5.1 Cable Configuration
2.5.2 Conductor Material
2.5.3 Insulation
2.5.4 Shielding
2.5.5 Neutrals
2.5.6 Jackets
2.6 MEDIUM VOLTAGE CABLE TERMINATIONS
2.6.1 Separable Insulated Connector Type
2.7 MEDIUM VOLTAGE CABLE JOINTS

2.7.1 Cold-Shrink Rubber-Type Joint
2.8 TAPE
2.8.1 Insulating Tape
2.8.2 Buried Warning and Identification Tape
2.8.3 Fireproofing Tape
2.9 PULL ROPE
2.10 GROUNDING AND BONDING
2.10.1 Driven Ground Rods
2.10.2 Grounding Conductors
2.11 CABLE TAGS IN MANHOLES
2.11.1 Polyethylene Cable Tags
2.12 SOURCE QUALITY CONTROL
2.12.1 Arc-Proofing Test for Cable Fireproofing Tape
2.12.2 Medium Voltage Cable Qualification and Production Tests

PART 3 EXECUTION

3.1 INSTALLATION
3.2 CABLE INSPECTION
3.3 CABLE INSTALLATION PLAN AND PROCEDURE
3.4 UNDERGROUND CONDUIT AND DUCT SYSTEMS
3.4.1 Requirements
3.4.2 Treatment
3.4.3 Conduit Cleaning
3.4.4 Multiple Conduits
3.4.5 Conduit Plugs and Pull Rope
3.4.6 Conduit and Duct Without Concrete Encasement
3.4.6.1 Encasement Under Roads and Structures
3.4.6.2 Directional Boring
3.4.7 Duct Encased in Concrete
3.4.7.1 Connections to Manholes
3.4.7.2 Connections to Existing Underground Structures
3.4.8 Duct Sealing
3.5 CABLE PULLING
3.5.1 Cable Lubricants
3.6 CABLES IN UNDERGROUND STRUCTURES
3.6.1 Cable Tag Installation
3.7 CONDUCTORS INSTALLED IN PARALLEL
3.8 LOW VOLTAGE CABLE SPLICING AND TERMINATING
3.9 MEDIUM VOLTAGE CABLE TERMINATIONS
3.10 MEDIUM VOLTAGE CABLE JOINTS
3.10.1 Joints in Shielded Cables
3.11 CABLE END CAPS
3.12 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES
3.12.1 Fireproofing Tape
3.13 GROUNDING SYSTEMS
3.13.1 Grounding Electrodes
3.13.2 Grounding Connections
3.13.3 Grounding Conductors
3.14 EXCAVATING, BACKFILLING, AND COMPACTING
3.14.1 Reconditioning of Surfaces
3.14.1.1 Unpaved Surfaces
3.14.1.2 Paving Repairs
3.15 FIELD QUALITY CONTROL
3.15.1 Performance of Field Acceptance Checks and Tests
3.15.1.1 Medium Voltage Cables
3.15.1.2 Low Voltage Cables, 600-Volt
3.15.1.3 Grounding System
3.15.2 Follow-Up Verification

-- End of Section Table of Contents --

SECTION 33 71 02

UNDERGROUND ELECTRICAL DISTRIBUTION
02/15

PART 1 GENERAL

1.1 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.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS8	(2013) Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 kV

ASTM INTERNATIONAL (ASTM)

ASTM B1	(2013) Standard Specification for Hard-Drawn Copper Wire
ASTM B3	(2013) Standard Specification for Soft or Annealed Copper Wire
ASTM B496	(2014) Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors
ASTM B8	(2011) Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM F2160	(2010) Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 386	(2006; INT 1 2011) Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V
IEEE 400.2	(2013) Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)
IEEE 404	(2012) Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V
IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth

	Surface Potentials of a Ground System
IEEE C2	(2012; Errata 1 2012; INT 1-4 2012; Errata 2 2013; INT 5-7 2013; INT 8-10 2014; INT 11 2015) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI C119.1	(2011) Electric Connectors - Sealed Insulated Underground Connector Systems Rated 600 Volts
ANSI/NEMA WC 71/ICEA S-96-659	(1999) Standard for Nonshielded Cables Rated 2001-5000 Volts for use in the Distribution of Electric Energy
NEMA TC 2	(2013) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 7	(2013) Standard for Smooth-Wall Coilable Electrical Polyethylene Conduit
NEMA TC 9	(2004) Standard for Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation
NEMA WC 74/ICEA S-93-639	(2012) 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-758	(2012b) Customer-Owned Outside Plant Telecommunications Infrastructure Standard

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 1751F-644	(2002) Underground Plant Construction

UNDERWRITERS LABORATORIES (UL)

UL 1072	(2006; Reprint Jun 2013) Medium-Voltage Power Cables

UL 44	(2014; Reprint Feb 2015) Thermoset-Insulated Wires and Cables
UL 467	(2007) Grounding and Bonding Equipment
UL 486A-486B	(2013; Reprint Feb 2014) Wire Connectors
UL 510	(2005; Reprint Jul 2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
UL 514B	(2012; Reprint Nov 2014) Conduit, Tubing and Cable Fittings
UL 6	(2007; Reprint Nov 2014) Electrical Rigid Metal Conduit-Steel
UL 651	(2011; Reprint May 2014) Standard for Schedule 40 and 80 Rigid PVC Conduit and Fittings
UL 854	(2004; Reprint Nov 2014) Standard for Service-Entrance Cables
UL 94	(2013; Reprint Jul 2015) Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

1.2 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE Stds Dictionary.

b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning.

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

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Medium voltage cable; G

Medium voltage cable joints; G

Medium voltage cable terminations; G

SD-06 Test Reports

Medium voltage cable qualification and production tests; G

Field Acceptance Checks and Tests; G

Arc-proofing test for cable fireproofing tape; G

Cable Installation Plan and Procedure; G

Six copies of the information described below in 8-1/2 by 11 inch binders having a minimum of three rings from which material may readily be removed and replaced, including a separate section for each cable pull. Separate sections by heavy plastic dividers with tabs, with all data sheets signed and dated by the person supervising the pull.

a. Site layout drawing with cable pulls numerically identified.

b. A list of equipment used, with calibration certifications. The manufacturer and quantity of lubricant used on pull.

c. The cable manufacturer and type of cable.

d. The dates of cable pulls, time of day, and ambient temperature.

e. The length of cable pull and calculated cable pulling tensions.

f. The actual cable pulling tensions encountered during pull.

SD-07 Certificates

Cable splicer/terminator; G

Cable Installer Qualifications; G

Directional Boring Certificate of Conformance; G

1.4 QUALITY ASSURANCE

1.4.1 Certificate of Competency for Cable Splicer/Terminator

Certification of the qualification of the cable splicer/terminator shall be submitted, for approval, 30 days before splices or terminations are to be made in medium voltage (5 kV to 35 kV) cables. The certification shall include the training, and experience of the individual on the specific type and classification of cable to be provided under this contract. The certification shall indicate that the individual has had three or more years recent experience splicing and terminating medium voltage cables. The certification shall also list a minimum of three splices/terminations that have been in operation for more than one year. In addition, the individual may be required to perform a dummy or practice splice/termination in the presence of the Contracting Officer, before being approved as a qualified cable splicer. If that additional requirement is imposed, the Contractor shall provide short sections of the approved types of cables along with the approved type of splice/termination kit, and detailed manufacturer's instructions for the cable to be spliced. The Contracting Officer reserves the right to require additional proof of

competency or to reject the individual and call for certification of an alternate cable splicer.

1.4.2 Cable Installer Qualifications

Provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations. Provide a resume showing the cable installers' experience in the last three years, including a list of references complete with points of contact, addresses and telephone numbers. Cable installer must demonstrate experience with a minimum of three medium voltage cable installations. The Contracting Officer reserves the right to require additional proof of competency or to reject the individual and call for an alternate qualified cable installer.

1.4.3 Directional Boring Certificate of Conformance

Provide certification of compliance with the registered Professional Engineer's design requirements for each directional bore, including: HDPE conduit size and type, bend radius, elevation changes, vertical and horizontal path deviations, conductor size and type and any conductor derating due to depth of conduit. Record location and depth of all directional-bore installed HDPE conduits using Global Positioning System (GPS) recording means with "resource grade" accuracy.

1.4.4 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship must be in accordance with the mandatory and advisory provisions of IEEE C2 and NFPA 70 unless more stringent requirements are specified or indicated.

1.4.5 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products must have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period must include applications of equipment and materials under similar circumstances and of similar size. The product must have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items must be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site are not acceptable, unless specified otherwise.

PART 2 PRODUCTS

2.1 CONDUIT, DUCTS, AND FITTINGS

2.1.1 Rigid Metal Conduit

UL 6.

2.1.2 Plastic Conduit for Direct Burial and Riser Applications

UL 651 and NEMA TC 2, EPC-80.

2.1.3 Plastic Duct for Concrete Encasement

Provide Type EPC-40 or EPC-80per UL 651 and NEMA TC 2.

2.1.4 High Density Polyethylene (HDPE) Electrical Conduit for Directional Boring

Smoothwall, approved/listed for directional boring, minimum Schedule 80, ASTM F2160, NEMA TC 7.

2.1.5 Duct Sealant

UL 94, Class HBF. Provide high-expansion urethane foam duct sealant that expands and hardens to form a closed, chemically and water resistant, rigid structure. Sealant must be compatible with common cable and wire jackets and capable of adhering to metals, plastics and concrete. Sealant must be capable of curing in temperature ranges of 35 degrees F to 95 degrees F. Cured sealant must withstand temperature ranges of -20 degrees F to 200 degrees F without loss of function.

2.1.6 Fittings

2.1.6.1 Metal Fittings

UL 514B.

2.1.6.2 PVC Conduit Fittings

UL 514B, UL 651.

2.1.6.3 PVC Duct Fittings

NEMA TC 9.

2.2 LOW VOLTAGE INSULATED CONDUCTORS AND CABLES

Insulated conductors must be rated 600 volts and conform to the requirements of NFPA 70, including listing requirements. Wires and cables manufactured more than 24 months prior to date of delivery to the site are not acceptable. Service entrance conductors must conform to UL 854, type USE.

2.2.1 Conductor Types

Cable and duct sizes indicated are for copper conductors and THHN/THWN unless otherwise noted. Conductors No. 10 AWG and smaller must be solid. Conductors No. 8 AWG and larger must be stranded. All conductors must be copper.

2.2.2 Conductor Material

Unless specified or indicated otherwise or required by NFPA 70, wires in conduit, other than service entrance, must be 600-volt, Type XHHW conforming to UL 44. Copper conductors must be annealed copper complying with ASTM B3 and ASTM B8.

2.2.3 Jackets

Multiconductor cables must have an overall PVC outer jacket.

2.2.4 In Duct

Cables must be single-conductor cable.

2.2.5 Cable Marking

Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout the cable length.

Identify each cable by means of a fiber, laminated plastic, or non-ferrous metal tags, or approved equal, in each manhole, handhole, junction box, and each terminal. Each tag must contain the following information; cable type, conductor size, circuit number, circuit voltage, cable destination and phase identification.

Conductors must be color coded. Provide conductor identification within each enclosure where a tap, splice, or termination is made. Conductor identification must be by color-coded insulated conductors, plastic-coated self-sticking printed markers, colored nylon cable ties and plates, heat shrink type sleeves,or colored electrical tape. Control circuit terminations must be properly identified. Color must be green for grounding conductors and white for neutrals; except where neutrals of more than one system are installed in same raceway or box, other neutrals must be white with a different colored (not green) stripe for each. Color of ungrounded conductors in different voltage systems must be as follows:

a. 208/120 volt, three-phase

(1) Phase A - black

(2) Phase B - red

(3) Phase C - blue

b. 480/277 volt, three-phase

(1) Phase A - brown

(2) Phase B - orange

(3) Phase C - yellow

c. 120/240 volt, single phase: Black and red

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS

Must provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

a. For use with copper conductors: UL 486A-486B.

2.4 LOW VOLTAGE SPLICES

Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and comply with ANSI C119.1.

2.4.1 Heat Shrinkable Splice

Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material applied in accordance with the manufacturer's written instructions.

2.5 MEDIUM VOLTAGE CABLE

Cable (conductor) sizes are designated by American Wire Gauge (AWG) and Thousand Circular Mils (Kcmil). Conductor and conduit sizes indicated are for copper conductors unless otherwise noted. Insulated conductors must have the date of manufacture and other identification imprinted on the outer surface of each cable at regular intervals throughout cable length. Wires and cables manufactured more than 24 months prior to date of delivery to the site are not acceptable. Provide single conductor type cables unless otherwise indicated.

2.5.1 Cable Configuration

Provide Type MV cable, conforming to NEMA WC 74/ICEA S-93-639 and UL 1072. Provide cables manufactured for use in duct applications. Cable must be rated 15 kV with 133 percent insulation level.

2.5.2 Conductor Material

Provide concentric-lay-stranded, Class B conductors. Provide soft drawn copper cables complying with ASTM B3 and ASTM B8 for regular concentric and compressed stranding or ASTM B496 for compact stranding.

2.5.3 Insulation

Provide ethylene-propylene-rubber (EPR) insulation conforming to the requirements of ANSI/NEMA WC 71/ICEA S-96-659.

2.5.4 Shielding

Cables rated for 2 kV and above must have a semiconducting conductor shield, a semiconducting insulation shield, and an overall copper tape shield for each phase.

2.5.5 Neutrals

Neutral conductors must be copper, employing the same insulation and jacket materials as phase conductors, except that a 600-volt insulation rating is acceptable.

2.5.6 Jackets

Provide cables with a PVC jacket. Provide PVC jackets with a separator that prevents contact with underlying semiconducting insulating shield.

2.6 MEDIUM VOLTAGE CABLE TERMINATIONS

Separable insulated connectors may be used for apparatus terminations, when such apparatus is provided with suitable bushings. Terminations, where required, must be provided with mounting brackets suitable for the intended installation and with grounding provisions for the cable shielding, metallic sheath, or armor. Terminations must be provided in a kit, including: skirts, stress control terminator, ground clamp, connectors, lugs, and complete instructions for assembly and installation. Terminations must be the product of one manufacturer, suitable for the type, diameter, insulation class and level, and materials of the cable terminated. Do not use separate parts of copper or copper alloy in contact with aluminum alloy parts in the construction or installation of the terminator.

2.6.1 Separable Insulated Connector Type

IEEE 386. Provide connector with steel reinforced hook-stick eye, grounding eye, test point, and arc-quenching contact material. Provide connectors of the loadbreak or deadbreak type as indicated, of suitable construction for the application and the type of cable connected, and that include cable shield adaptors. Provide external clamping points and test points. Separable connectors must not be used in manholes/handholes.

a. 200 Ampere loadbreak connector ratings: Voltage: 15 kV, 95 kV BIL. Short time rating: 10,000 rms symmetrical amperes.

2.7 MEDIUM VOLTAGE CABLE JOINTS

Provide joints (splices) in accordance with IEEE 404 suitable for the rated voltage, insulation level, insulation type, and construction of the cable. Joints must be certified by the manufacturer for waterproof, submersible applications. Upon request, supply manufacturer's design qualification test report in accordance with IEEE 404. Connectors for joint must be tin-plated electrolytic copper, having ends tapered and having center stops to equalize cable insertion.

2.7.1 Cold-Shrink Rubber-Type Joint

Joint must be of a cold shrink design that does not require any heat source for its installation. Splice insulation and jacket must be of a one-piece factory formed cold shrink sleeve made of black EPDM rubber. Splice must be packaged three splices per kit, including complete installation instructions.

2.8 TAPE

2.8.1 Insulating Tape

UL 510, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.8.2 Buried Warning and Identification Tape

Provide detectable tape in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL.

2.8.3 Fireproofing Tape

Provide tape composed of a flexible, conformable, unsupported intumescent elastomer. Tape must be not less than .030 inch thick, noncorrosive to cable sheath, self-extinguishing, noncombustible, adhesive-free, and must not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.9 PULL ROPE

Plastic or flat pull line (bull line) having a minimum tensile strength of 200 pounds.

2.10 GROUNDING AND BONDING

2.10.1 Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 3/4 inch in diameter by 10 feet in length.

2.10.2 Grounding Conductors

Stranded-bare copper conductors must conform to ASTM B8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors must conform to ASTM B1 for sizes No. 8 and smaller. Insulated conductors must be of the same material as phase conductors and green color-coded, except that conductors must be rated no more than 600 volts. Aluminum is not acceptable.

2.11 CABLE TAGS IN MANHOLES

Provide tags for each power cable located in manholes. The tags must be polyethylene. Do not provide handwritten letters. The first position on the power cable tag must denote the voltage. The second through sixth positions on the tag must identify the circuit. The next to last position must denote the phase of the circuit and include the Greek "phi" symbol. The last position must denote the cable size. As an example, a tag could have the following designation: "11.5 NAS 1-8(Phase A)500," denoting that the tagged cable is on the 11.5kV system circuit number NAS 1-8, underground, Phase A, sized at 500 kcmil.

2.11.1 Polyethylene Cable Tags

Provide tags of polyethylene that have an average tensile strength of 3250 pounds per square inch; and that are 0.08 inch thick (minimum), non-corrosive non-conductive; resistive to acids, alkalis, organic solvents, and salt water; and distortion resistant to 170 degrees F.

Provide 0.05 inch (minimum) thick black polyethylene tag holder. Provide a one-piece nylon, self-locking tie at each end of the cable tag. Ties must have a minimum loop tensile strength of 175 pounds. The cable tags must have black block letters, numbers, and symbols one inch high on a yellow background. Letters, numbers, and symbols must not fall off or change positions regardless of the cable tags' orientation.

2.12 SOURCE QUALITY CONTROL

2.12.1 Arc-Proofing Test for Cable Fireproofing Tape

Manufacturer must test one sample assembly consisting of a straight lead tube 12 inches long with a 2 1/2 inch outside diameter, and a 1/8 inch thick wall, and covered with one-half lap layer of arc and fireproofing tape per manufacturer's instructions. The arc and fireproofing tape must withstand extreme temperature of a high-current fault arc 13,000 degrees K for 70 cycles as determined by using an argon directed plasma jet capable of constantly producing and maintaining an arc temperature of 13,000 degrees K. Temperature (13,000 degrees K) of the ignited arc between the cathode and anode must be obtained from a dc power source of 305 (plus or minus 5) amperes and 20 (plus or minus 1) volts. The arc must be directed toward the sample assembly accurately positioned 5 (plus or minus 1) millimeters downstream in the plasma from the anode orifice by fixed flow rate of argon gas (0.18 g per second). Each sample assembly must be tested at three unrelated points. Start time for tests must be taken from recorded peak current when the specimen is exposed to the full test temperature. Surface heat on the specimen prior to that time must be minimal. The end point is established when the plasma or conductive arc penetrates the protective tape and strikes the lead tube. Submittals for arc-proofing tape must indicate that the test has been performed and passed by the manufacturer.

2.12.2 Medium Voltage Cable Qualification and Production Tests

Results of AEIC CS8 qualification and production tests as applicable for each type of medium voltage cable.

PART 3 EXECUTION

3.1 INSTALLATION

Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of NFPA 70 and IEEE C2 as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758 and RUS Bull 1751F-644.

3.2 CABLE INSPECTION

Inspect each cable reel for correct storage positions, signs of physical damage, and broken end seals prior to installation. If end seal is broken, remove moisture from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE

Obtain from the manufacturer an installation manual or set of instructions which addresses 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. Prepare a checklist of significant requirements. Perform pulling calculations and prepare a pulling plan and submit along with the manufacturer's instructions in accordance with SUBMITTALS. Install cable strictly in accordance with the cable manufacturer's recommendations and the approved installation plan.

Calculations and pulling plan must include:

a. Site layout drawing 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.

d. Procedure for resealing cable ends to prevent moisture from entering cable.

e. Cable pulling tension calculations of all cable pulls.

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.

j. Maximum allowable pulling tension on each different type and size of conductor.

k. Maximum allowable pulling tension on pulling device.

3.4 UNDERGROUND CONDUIT AND DUCT SYSTEMS

3.4.1 Requirements

Run conduit in straight lines except where a change of direction is necessary. Provide numbers and sizes of ducts as indicated. Provide a 4/0 AWG bare copper grounding conductor above medium-voltage distribution duct banks. Bond bare copper grounding conductor to ground rings (loops) in all manholes and to ground rings (loops) at all equipment slabs (pads). Route grouding conductor into manholes with the duct bank (sleeving is not required). Ducts must have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 3 inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Provide ducts with end bells whenever duct lines terminate in structures.

Perform changes in ductbank direction as follows:

a. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable.

b. The minimum manufactured bend radius must be 18 inches for ducts of less than 3 inch diameter, and 36 inches for ducts 3 inches or greater

in diameter.

c. As an exception to the bend radius required above, provide field manufactured longsweep bends having a minimum radius of 25 feet for a change of direction of more than 5 degrees, either horizontally or vertically, using a combination of curved and straight sections. Maximum manufactured curved sections: 30 degrees.

3.4.2 Treatment

Ducts must be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers must be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer must be used whenever an existing duct is connected to a duct of different material or shape. Ducts must be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts must be thoroughly cleaned before being laid. Plastic ducts must be stored on a flat surface and protected from the direct rays of the sun.

3.4.3 Conduit Cleaning

As each conduit run is completed, for conduit sizes 3 inches and larger, draw a flexible testing mandrel approximately 12 inches long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. 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.

3.4.4 Multiple Conduits

Separate multiple conduits by a minimum distance of 3 inches, except that light and power conduits must be separated from control, signal, and telephone conduits by a minimum distance of 12 inches. Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly must consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 10 feet of conduit assembly.

3.4.5 Conduit Plugs and Pull Rope

New conduit indicated as being unused or empty must be provided with plugs on each end. Plugs must contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 3 feet of slack at each end of unused or empty conduits.

3.4.6 Conduit and Duct Without Concrete Encasement

3.4.6.1 Encasement Under Roads and Structures

Under roads and paved areas, install conduits in concrete encasement of rectangular cross-section providing a minimum of 3 inch concrete cover around ducts. Concrete encasement must extend at least 5 feet beyond the edges of paved areas and roads. Depths to top of the concrete envelope

must be not less than 24 inches below finished grade.

3.4.6.2 Directional Boring

HDPE conduits must be installed as specified herein.

For distribution voltages greater than 1000 volts and less than 34,500 volts, depths to the top of the conduit must not be less than 48 inches in pavement-covered areas and not less than 120 inches in non-pavement-covered areas. For distribution voltages less than 1000 volts, depths to the top of the conduit must not be less than 48 inches in pavement- or non-pavement-covered areas. For branch circuit wiring less than 600 volts, depths to the top of the conduit must not be less than 24 inches in pavement- or non-pavement-covered areas.

3.4.7 Duct Encased in Concrete

Construct underground duct lines of individual conduits encased in concrete. Depths to top of the concrete envelope must be not less than 18 inches below finished grade, except under roads and pavement, concrete envelope must be not less than 24 inches below finished grade. Concrete encasement surrounding the bank must be rectangular in cross-section and must provide at least 3 inches of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 3 inches. Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring must be done by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly. Provide steel reinforcing in the concrete envelope as indicated. Provide color, type and depth of warning tape as specified in Section 31 23 00.00 20 EXCAVATION AND FILL.

3.4.7.1 Connections to Manholes

Duct bank envelopes connecting to underground structures must be flared to have enlarged cross-section at the manhole entrance to provide additional shear strength. Dimensions of the flared cross-section must be larger than the corresponding manhole opening dimensions by no less than 12 inches in each direction. Perimeter of the duct bank opening in the underground structure must be flared toward the inside or keyed to provide a positive interlock between the duct bank and the wall of the structure. Use vibrators when this portion of the encasement is poured to assure a seal between the envelope and the wall of the structure.

3.4.7.2 Connections to Existing Underground Structures

For duct bank connections to existing structures, break the structure wall out to the dimensions required and preserve steel in the structure wall. Cut steel and bend out to tie into the reinforcing of the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

3.4.8 Duct Sealing

Seal all electrical penetrations for radon mitigation, maintaining integrity of the vapor barrier, and to prevent infiltration of air, insects, and vermin.

3.5 CABLE PULLING

Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables. Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable bending radii when installing cable under any conditions, including turnups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape shield must have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.5.1 Cable Lubricants

Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.6 CABLES IN UNDERGROUND STRUCTURES

Do not install cables utilizing the shortest path between penetrations, but route along those walls providing the longest route and the maximum spare cable lengths. Form cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath. Install cables at middle and bottom of cable racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure.

3.6.1 Cable Tag Installation

Install cable tags in each manhole as specified, including each splice. Tag wire and cable provided by this contract. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes.

3.7 CONDUCTORS INSTALLED IN PARALLEL

Conductors must be grouped such that each conduit of a parallel run contains 1 Phase A conductor, 1 Phase B conductor, 1 Phase C conductor, and 1 neutral conductor.

3.8 LOW VOLTAGE CABLE SPLICING AND TERMINATING

Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. Make splices in underground distribution systems only in accessible locations such as manholes, handholes, or aboveground termination pedestals.

3.9 MEDIUM VOLTAGE CABLE TERMINATIONS

Make terminations in accordance with the written instruction of the termination kit manufacturer.

3.10 MEDIUM VOLTAGE CABLE JOINTS

Provide power cable joints (splices) suitable for continuous immersion in water. Make joints only in accessible locations in manholes or handholes by using materials and methods in accordance with the written instructions of the joint kit manufacturer.

3.10.1 Joints in Shielded Cables

Cover the joined area with metallic tape, or material like the original cable shield and connect it to the cable shield on each side of the splice. Provide a bare copper ground connection brought out in a watertight manner and grounded to the manhole grounding loop as part of the splice installation. Ground conductors, connections, and rods must be as specified elsewhere in this section. Wire must be trained to the sides of the enclosure to prevent interference with the working area.

3.11 CABLE END CAPS

Cable ends must be sealed at all times with coated heat shrinkable end caps. Cables ends must be sealed when the cable is delivered to the job site, while the cable is stored and during installation of the cable. The caps must remain in place until the cable is spliced or terminated. Sealing compounds and tape are not acceptable substitutes for heat shrinkable end caps. Cable which is not sealed in the specified manner at all times will be rejected.

3.12 FIREPROOFING OF CABLES IN UNDERGROUND STRUCTURES

Fireproof (arc proof) wire and cables which will carry current at 2200 volts or more in underground structures.

3.12.1 Fireproofing Tape

Tightly wrap strips of fireproofing tape around each cable spirally in half-lapped wrapping. Install tape in accordance with manufacturer's instructions.

3.13 GROUNDING SYSTEMS

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

3.13.1 Grounding Electrodes

Provide cone pointed driven ground rods driven full depth plus 12 inches, installed to provide an earth ground of the appropriate value for the particular equipment being grounded.
If the specified ground resistance is not met, an additional ground rod must be provided in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, notify the Contracting Officer immediately.

3.13.2 Grounding Connections

Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds.

b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies must be as recommended by the manufacturer. An embossing die code or other standard method must provide visible indication that a connector has been adequately compressed on the ground wire.

3.13.3 Grounding Conductors

Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with No. 6 AWG. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of No. 6 AWG.

3.14 EXCAVATING, BACKFILLING, AND COMPACTING

Provide in accordance with NFPA 70 and Section 31 23 00.00 20 EXCAVATION AND FILL.

3.14.1 Reconditioning of Surfaces

3.14.1.1 Unpaved Surfaces

Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct. Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

3.14.1.2 Paving Repairs

Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists, restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.

3.15 FIELD QUALITY CONTROL

3.15.1 Performance of Field Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.15.1.1 Medium Voltage Cables

Perform tests after installation of cable, splices, and terminators and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Inspect for proper shield grounding, cable support, and cable termination.

(4) Verify that cable bends are not less than ICEA or manufacturer's minimum allowable bending radius.

(5) Inspect for proper fireproofing.

(6) Visually inspect jacket and insulation condition.

(7) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform a shield continuity test on each power cable by ohmmeter method. Record ohmic value, resistance values in excess of 10 ohms per 1000 feet of cable must be investigated and justified.

(2) Perform acceptance test on new cables before the new cables are connected to existing cables and placed into service, including terminations and joints. Perform maintenance test on complete cable system after the new cables are connected to existing cables and placed into service, including existing cable, terminations, and joints. Tests must be very low frequency (VLF) alternating voltage withstand tests in accordance with IEEE 400.2. VLF test frequency must be 0.05 Hz minimum for a duration of 60 minutes using a sinusoidal waveform. Test voltages must be as follows:

CABLE RATING AC TEST VOLTAGE for ACCEPTANCE TESTING	
5 kV	10kV rms(peak)
8 kV	13kV rms(peak)
15 kV	20kV rms(peak)
25 kV	31kV rms(peak)
35 kV	44kV rms(peak)

CABLE RATING AC TEST VOLTAGE for MAINTENANCE TESTING	
5 kV	7kV rms(peak)
8 kV	10kV rms(peak)

CABLE RATING AC TEST VOLTAGE for MAINTENANCE TESTING	
15 kV	16kV rms(peak)
25 kV	23kV rms(peak)
35 kV	33kV rms(peak)

3.15.1.2 Low Voltage Cables, 600-Volt

Perform tests after installation of cable, splices and terminations and before terminating to equipment or splicing to existing circuits.

a. Visual and Mechanical Inspection

(1) Inspect exposed cable sections for physical damage.

(2) Verify that cable is supplied and connected in accordance with contract plans and specifications.

(3) Verify tightness of accessible bolted electrical connections.

(4) Inspect compression-applied connectors for correct cable match and indentation.

(5) Visually inspect jacket and insulation condition.

(6) Inspect for proper phase identification and arrangement.

b. Electrical Tests

(1) Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 1000 volts dc for one minute.

(2) Perform continuity tests to insure correct cable connection.

3.15.1.3 Grounding System

a. Visual and mechanical inspection

Inspect ground system for compliance with contract plans and specifications.

b. Electrical tests

Perform ground-impedance measurements utilizing the fall-of-potential method in accordance with IEEE 81. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument must be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test. Provide site diagram indicating location of test probes with associated

distances, and provide a plot of resistance vs. distance.

3.15.2 Follow-Up Verification

Upon completion of acceptance checks and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Contracting Officer must be given 5 working days advance notice of the dates and times of checking and testing.

-- End of Section --