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USACE / NAVFAC / AFCESA / NASA **UFGS 27 13 23.00 40 (November 2008)**

Preparing Activity: NASA **Superseding UFGS 40 95 33.23 40 (July 2007)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2012
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DIVISION 27 - COMMUNICATIONS

SECTION 27 13 23.00 40

COMMUNICATIONS OPTICAL BACKBONE CABLING

11/08

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SECTION 27 13 23.00 40

COMMUNICATIONS OPTICAL BACKBONE CABLING
11/08

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NOTE: This guide specification covers the requirements for requirements for fiber optic cable systems.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****

PART 1 GENERAL

1.1 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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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 C338	(1993; R 2008) Standard Test Method Softening Point of Glass
ASTM D4976	(2012) 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 2012; INT 1 2012; INT 2 2012) 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 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA RN 1	(2005) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
NEMA TC 2	(2003) Standard for Electrical Polyvinyl Chloride (PVC) Conduit
NEMA TC 3	(2004) Standard for Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit and Tubing
NEMA TC 6 & 8	(2003) 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	(2011; Errata 2 2012) 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 2000; R 2005) 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-455-177	(2003b) FOTP-177 IEC-60793-1-43: Measurement Methods and Test Procedures - Numerical Aperture
TIA-455-33	(2005b) 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-526-14	(2010b) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
TIA-526-7	(2002; R 2008) 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; Corrections 2008) Optical Fiber Cabling Components Standard
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) 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-569-A	(1998; Addenda 2000, 2001) Commercial Building Standards for Telecommunications Pathways and Spaces
TIA/EIA-598	(2005c) Optical Fiber Cable Color Coding
TIA/EIA-604-3	(2000b) 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. DEPARTMENT OF DEFENSE (DOD)	
MIL-STD-188-176	(1996; Notice 1) Standardized Profile for Asynchronous Transfer Mode (ATM)
MIL-STD-2042	(2002; Rev B; Notice 1 2007) Fiber Optic Cable Topology Installation Standard Methods for Naval Ships
U.S. GENERAL SERVICES ADMINISTRATION (GSA)	
FED-STD-595	(Rev C; Notice 1) Colors Used in Government Procurement

1.2 GENERAL REQUIREMENTS

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NOTE: If Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS is not included in the project specification, applicable requirements therefrom should be inserted and the following paragraph

deleted.

****

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

Fiber optic cable shall consist of optical fibers, strength member[s], and jacketing. Associated components shall include optical fiber connectors, optical patch panels, terminal bay cabinets, and splice closures as indicated. Install fiber optic cables in inner duct in the existing cable duct and manhole system and/or directly buried to the facility. Locate fiber optic terminal in existing facility buildings.

References in this section to cable shall refer to fiber optic cable.

1.3 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Submit the following preconstruction submittals to the Contracting Officer for approval and approved [30] [_____] calendar days prior to installation.

Qualifications

Quality Assurance Plan

SD-02 Shop Drawings

Fiber Optic System[; G][; G, [_____]]

SD-03 Product Data

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

Optical Fibers

Fiber Optic Cable Design

Splice Organizers

Pre-Connected Cable Assembly

Fiber Optic Terminal Cabinets

Optical Patch Panel Assemblies

Fiber Optic Media Types[; G][; G, [_____]]

Fiber Optic Terminations and Connectors Material Data[; G][; G, [_____]]

Fiber Optic Enclosures[; G][; G, [_____]]

SD-06 Test Reports

Submit contractor test reports for approval to the Technical Representative not later than [14] [_____] calendar days after the completion of each test.

Factory Test Certificates

Single and Multi-mode OTDR Test

End-to-End Attenuation Tests

End-to-End Bandwidth Tests

Fiber Optic Factory Test Plan[; G][; G, [_____]]

Fiber Optic Field Tests Plan[; G][; G, [_____]]

SD-07 Certificates

Fiber Optic Cable Installer and Splicer Qualifications; G

Manufacturer's qualifications[; G][; G, [_____]]

SD-08 Manufacturer's Instructions

Fiber optic system instructions[; G][; G, [_____]]

1.4 QUALIFICATIONS

Cable construction work shall be performed by construction personnel who have had at least [3] [_____] years experience in placing cables in conduit, cable trays, and underground duct systems.

Fiber optic cable splices, terminations and testing shall be made by journeymen cable splicers who have had a minimum of [1] [_____] year experience in splicing and terminating fiber optic cables. Personnel working pursuant to this section, may at the Contracting Officer's option, be required to demonstrate technical competence by performing sample work [and/or by displaying their state qualifications/certificates], at no additional cost to the Government.

Each person who is to perform fiber optic cable splicing shall perform a minimum of one acceptable sample splice and termination. Do not incorporate sample splices and terminations in the job.

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, 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.

1.5 QUALITY ASSURANCE PLAN

Contractor shall prepare a quality assurance plan which provides a detailed outline of all testing to be accomplished. Quality assurance plan shall address 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 shall include, 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 shall conform to the specified requirements.

1.5.1 Fiber Optic System

Provide 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. Drawings shall be 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. System drawings shall show final configuration, including location, fiber pair count, pathway innerduct arrangement, and pathway assignment of outside plant. FO system shall be compatible with MIL-STD-188-176. Design Pier FO systems for compatibility with MIL-STD-2042 and NAVSEA drawings.

****
Note: Design drawings shall provide physical location details for aerial poles, underground media routes, maintenance holes, handholes, ducts, duct banks, pathways, cable markers, and related hardware. Show telecommunications rooms, closets, and backboards on drawings. Provide a telecommunications media schedule on the drawings with FO pair, counts, media length and pathway length. Designer shall perform pathway fill, (max 40 percent), and media tension calculations for all runs. Materials must be listed as RUS certified for the application (http://www.usda.gov/rus/telecom/materials/material.htm). Design drawings shall provide details for installation of the FO cable in accordance with EIA/TIA-590.
****

1.5.2 Fiber Optic Cable Installer and Splicer Qualifications

Technicians installing FO media, splices and performing system tests shall be certified and trained in accordance with an approved manufacturers training program. Technicians shall have 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 shall include the training, and experience of the individual on specific type and classification of FO media to be provided under this contract.

1.5.3 Fiber Optic System Instructions

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

1.5.4 Manufacturer's Qualifications

The FO media manufacturer shall have a minimum of 3 years experience in the manufacturing, assembly, and factory testing of FO media which comply with RUS Bull 1753F-601. Manufacturer must provide a list of customers with 3 years of maintenance logs documenting experience with government customers.

1.5.5 Fiber Optic Factory Test Plan

Prepare and provide the government for review a test plan for factory and field tests of the FO media. Provide factory 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/EIA-569-A 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.

1.5.6 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 and EIA TIA/EIA-526-14A for multi mode fiber.

1.6 DELIVERY, STORAGE, AND HANDLING

Ship media to job site on factory reels or in factory cartons. Radius of the reel drum shall not be 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. Two meters of cable at each end of the reel must be readily accessible for testing. Provide 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. Reels with cable shall be suitable for outside storage conditions when temperature ranges from minus 40 degrees C to plus 65 degrees C, with relative humidity from zero to 100 percent. Equipment, other than FO media, delivered and placed in storage shall be stored with protection from weather, humidity and temperature variation, dirt and dust, or other contaminants.

Exercise care in handling materials during construction. Contractor shall ensure that the buried cable is fed through the plow into the ground at zero tension. Do not allow tension to develop in the cable.

Whenever the plow is stopped, sufficient cable shall be unreeled to guard against sudden jerks when the plow is started.

Exercise caution to ensure that the plow is not backed up while the blade is in the ground. Cable can be severely damaged by the plow backing up even a slight amount. During the plowing operation, the plow may strike a buried object or rock that would stop the equipment and necessitate removal of the plow from the ground. When this occurs, remove the plow carefully without backing up. When it is necessary to back the plow, uncover the cable a sufficient distance back from the plow for inspection by the Contracting Officer to determine if there is any damage. Immediately report any damage to the Contracting Officer. Repair or replace damages as directed by the Contracting Officer.

1.7 RELATED REQUIREMENTS

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NOTE: Coordinate with Sections 33 71 02.00 20 UNDERGROUND TRANSMISSION AND DISTRIBUTION, and Section 26 05 33 DOCKSIDE POWER CONNECTION STATIONS. For LANTNAVFACENGCOM projects, use SeL-16303N UNDERGROUND ELECTRICAL WORK in lieu of Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION.

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Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS applies to this section with additions and modifications specified herein.

PART 2 PRODUCTS

2.1 FIBER OPTIC CABLE DESIGN

2.1.1 Fiber Optic Media Types

FO media shall meet 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.

****

Note: Designer shall specify requirements for Fiber Optic media from the following selections:

Fiber Optic Media Type:
(single mode) (multi mode) (hybrid)

Fiber Count: [12][24][48][ ][216]

Media Optic Characteristics:
Fiber core diameter: [50]mmf [62.5]mmf or [ ]smf
Bandwidth 850nm mHz/km: [500]50μm [160] 62.5μm
Bandwidth 1300nm mHz/km: [500]50μm [500]62.5μm
Attenuation 850nm dB: [2.5]50μm [3.0]62.5μm
Attenuation 1300nm dB: [0.8]50μm [0.7]62.5μm
Bending Radius mm: [30]50μm [30]62.6μm [30]smf

****

2.1.1.1 Multi Mode Fiber Media

Provide FO media with outer sheath jacket,[strength member,] ripcords, water blocking material,[optional steel shield,] core tube, and core fibers as installed in a permanent underground pathway system as shown on the construction drawings. FO media shall have an all glass, graded index material with a nominal core diameter of [62.5][____] microns. Provide a cladding material for the fiber which is compatible with the core. Media transmission window shall be centered at 850 and 1300 nanometer wavelengths, attenuation at 1300 nanometers shall be less than [2.0][____] dB per kilometer. Minimum bandwidth shall be 500 mHz-Km.

****

NOTE: The designer shall specify the number of fiber strands. The minimum number of fiber to a facility or building shall be 12 plus 25 percent spare capacity. Designer shall specify loose tube or tight tube design. In general gelatin filled media should be used unless tight tube is required to interface with customer terminal equipment. The loose tube construction is more appropriate where media is subject to numerous bends along the cable route. This includes aerial and long distance runs (over one Km). Tight tube design may be used for exterior direct burial in ducts below the frost line. For Navy projects the preferred underground installation is within a pathway system compliant with EIA/TIA-569. Direct burial installations shall comply with EIA/TIA-590. Media for Defense Information System Agency (DISA) equipment connection shall comply with Mil-Std-188-176.

****

2.1.1.2 Single Mode Fiber Media.

Provide FO single mode media with outer sheath jacket,[strength member,] ripcords, water blocking material,[optional steel shield,] core tube, and core fibers as installed in a permanent underground pathway system as shown on the construction drawings. Media shall have 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. Fiber cladding diameter shall be nominal 125 microns. Media shall have a transmission window centered at 1300 and 1550 nanometer wavelengths, attenuation at 1550 nanometers shall be less than 0.5 dB per kilometer. FO media shall comply with TIA/EIA-472DAAA,and TIA-758.

2.1.2 Cable Length

Cable shall be manufactured continuous with no factory splices.

2.1.3 Materials and Construction

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

Minimum required material components applied to fiber optic cable construction shall be 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.

2.1.3.1 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. Material of the central core member shall be non-metallic.

2.1.3.2 Optical Fibers

Two types of optical fibers, single-mode fiber and multi-mode fiber, shall be contained in the cable and shall be as follows:

Single-Mode (SM) fiber must be the equivalent [step] [graded] index optical glass. Core diameter of the fiber shall be approximately 8.7 micrometer. Cladding diameter shall be 125 plus or minus 3 micrometer. Core cladding offset shall be less than 1 micrometer. Minimum tensile strength of the fiber after primary protective coating shall be greater than 350,000 kilopascal 50,000 psi . Softening point of the clad material of the optical fiber shall be 1630 degrees C plus or minus 50 degrees C in accordance with ASTM C338, or the optical fiber shall meet the requirements in paragraph entitled, "Splice Compatibility Test."

Multi-Mode (MM) fiber shall be the [graded] [step] index optical glass. Core diameter of the fiber shall be [50] [62.5] plus or minus 3 micrometer. Cladding diameter shall be 125 plus or minus 3 micrometer. Core-cladding offset shall be less than 3 micrometer. Minimum tensile

strength of the fiber after primary protective coating shall be greater than 350,000 kilopascal 50,000 psi. Softening point of the clad material of the optical fiber shall be 1630 degrees C plus or minus 50 degrees C in accordance with ASTM C338, or the optical fiber shall meet the requirements in paragraph entitled, "Splice Compatibility Test."

2.1.3.3 Fiber Primary Protective Coating

Coat optical fiber with suitable material to preserve the intrinsic high tensile strength of the glass fiber. Outside diameter of the coated optical fiber shall be 250 plus or minus 15 micrometer. Coating material shall be readily removable, mechanically or chemically, without damaging the optical fibers when the removal is desired.

2.1.3.4 Optical Fiber Color-Code Coating

Primary protective coated SM and MM fibers shall be coated with a color-code coating for individual fiber identification. Maximum outside diameter of color-code coated fiber shall be less than 300 micrometer.

2.1.3.5 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. Material of the buffering tube shall be [PVC] [mylar] [nylon] [_____].

2.1.3.6 Colorants

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

2.1.3.7 Number of Fibers Per Tube Per Cable

36-fiber cable and 72-fiber cable are required and shall be as follows:

36-fiber cable shall contain multimode and single mode fibers. Cable core configuration shall be comprised of six loose buffer tubes, each containing six fibers. Six fibers in each loose buffer tube shall be color coded using the first colors of the standard Munsell color code, Blue, Orange, Green, Brown, Slate, and White. Loose buffer tubes shall be color coded using the standard Munsell color code, Blue, Orange, Green, Brown and Slate. Sixth buffer tube shall be Pink. Consider single mode fibers last in configuration.

72-fiber cable shall contain multimode and single mode fibers. Cable core configuration shall be comprised of 12 loose buffer tubes, each containing six fibers. Six fibers in each loose buffer tube shall be color coded using the first colors of the standard Munsell color code, Blue, Orange, Green, Brown, Slate and White. Color code loose buffer tubes using the standard Munsell color code, Blue, Orange, Green, Brown, Slate, Red, Black, Yellow, and Violet. Eleventh and twelfth buffer tubes shall be Blue/White and Orange/White, respectively. Consider single mode fibers last in configuration.

2.1.3.8 Inner Jacket

Locate buffer tubes concentrically around the cable central core member and covered with a polyethylene inner jacket. Polyethylene inner jacket shall be [high] [medium] density polyethylene in accordance with ASTM D4976. Space between the buffer tubes and inner jacket shall be filled with a gel compound to prevent air, moisture, or water intrusion in the inner jacket.

2.1.3.9 Filling Compound

Inner jacket interior and loose tube buffer cavity shall contain a gel-type filling compound. Filling compound shall be of suitable viscosity so that it will protect the optical fibers against the ingress of water and/or soluble chemicals and shall not flow at the temperature of up to 65 degrees C. Gel filling compound shall be 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. Gel filling compound shall be removable, as required, using commercially available products under field-type conditions.

2.1.3.10 Pulling Strength Member

Use a ramid type material as pulling strength members in the cable to provide pulling strength of at least [1800] [_____] newton [400] [_____] pounds for the cable during installation.

2.1.3.11 Cable Outer Jacket

Black [high] [medium] density, high-molecular weight, polyethylene materials in accordance with ASTM D4976 shall be applied longitudinally over all the inner jacket and sheathing strength member to form the cable outer jacket. Outer jacket shall be smooth, concentric, non-nutrient to fungus, and free from holes, splits, blisters, or other imperfections. Overall outside cable diameter shall not exceed [19] [_____] millimeter [0.75] [_____] inch.

2.1.3.12 Metallic Armor

Provide a metallic armor shield for direct buried cable for additional tensile strength, rodent protection, and high crush and moisture resistance. Material of the metallic armoring shall be metallic tube or steel corrugation-coated with anti-corrosion material, sealed at the longitudinal overlap.

2.2 CABLE IDENTIFICATION SYMBOL

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

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

Third character shall be a slash.

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

Fourth character shall be 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. Character shall be an "O" if these requirements are not met.

Fifth character shall be 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. Character shall be an "O" 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.
and FS05 : 13-24	Identifies Single Mode Fiber Cable 05 with SM Fibers 13 through 24.

2.3 REPLACEMENT CABLE

In addition to the cable sections indicated, a reel of each size and type of the manufacturer's furnished cable, provide not less than 0.5 kilometers.

2.4 SPLICE ORGANIZERS

Single mode or multi-mode fibers shall be fusion spliced with a protective sleeve covering and stored in an organizer with a minimum of 450 millimeter 18 inches spare coiled buffer tubing. Single mode fibers shall be spliced last in the splice tray.

Complete a [72] [_____] fiber splice in an outer closure. Organizer assembly, with one tray containing [12] [_____] fusion splices each requires [five] [_____] extra trays, to form the section complete in the inner closure.

Fill space between the inner and outer closures with encapsulating fluid. Factory drill end plates to fit the cable(s) outer diameter.

2.5 PRE-CONNECTED CABLE ASSEMBLY

Contractor shall supply factory assembled pre-connectorized cable assembly to interface with the patch panel bulkhead feed-through receptacle. Contractor shall supply and install dust caps for all terminated fibers.

Multi-mode fiber optic cable assembly shall be comprised of a single fiber connector, terminated on [three (3)] [_____] meter length of single fiber, multi-mode cable. Single fiber cable shall contain a buffered optical fiber and be the same as that provided in the multi-fiber cable.

Single fiber optic cable assembly shall be comprised of a single fiber connector terminated on the [three (3)] [_____] meter length of single fiber, single mode cable. Single fiber cable shall contain a buffered optical fiber and be the same as that provided in the multi-fiber cable. Return loss for single mode connectors shall be a minimum of [minus 30dB] [_____].

Connector/cable interface on both the single and multi-mode cable assemblies shall be able to withstand a tensile force of [110] [_____] newton [25] [_____] pounds without detrimental affects on the connector loss characteristics.

Each connectorized cable assembly shall have a loss of less than or equal to [0.5 dB] [_____].

2.6 OPTICAL PATCH PANEL ASSEMBLIES

Make all cable terminations in optical patch panel assemblies. Patch panel assemblies shall be of the pre-assembled chassis type with associated rack-mounting hardware.

To facilitate the transition between outside plant cable and the preconnectorized cable assemblies, the fibers shall be [fusion] [mechanical] spliced and housed in a splice tray. Position splice tray in the optical patch panel assembly as indicated. Splice attenuation shall not exceed [0.2] [_____] db. Cover splice with a protective sleeve.

2.7 FIBER OPTIC TERMINAL CABINETS

FOT cabinets shall be front recess only. Cabinet's frame shall consist of vertical and horizontal tubular aluminum extrusions with a minimum wall thickness of [3.81] [_____] millimeter [.150] [_____] inches. Front to rear aluminum extruded corners shall be at least [3.18] [_____] millimeter [.125] [_____] inches thick. Rear door, top panel, and side panels shall be a minimum of [1.3] [_____] millimeter [18] [_____]-gage steel. Provide cabinet with [1.9] [_____] millimeter [14] [_____] gage steel, [7.14] [_____] millimeter [.281] [_____] inches punched panel/chassis mounting rails permitting recessed installation of equipment. Place cable entry and exit holes as indicated. Dimensions of cabinet and associated cabinet hardware shall be as indicated.

Cabinet shall be gray in color in accordance with FED-STD-595.

2.8 FACTORY TEST CERTIFICATES

Fiber optical cable shall comply with the following optical and mechanical test requirements.

2.8.1 Optical Performance

2.8.1.1 Multi-Mode Fibers in the Cable

Optical attenuation of each optical fiber in the cable (reeled) shall be no greater than 1.0 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.

Bandwidth at minus 3 dB optical power of each optical fiber in the cable (reeled) shall be a bandwidth length product, gamma equals 1, greater than 1 GHz-Km at 1300 plus or minus 50 nm optical spectrum window.

Numerical aperture of each optical fiber shall be 0.2 plus or minus 0.015 at 1300 nm optical spectrum window. Method of numerical aperture measurement shall be in accordance with TIA-455-177, at central wavelength 1300 nm nominal. When this requirement is not met, apply the fusion splice

compatibility test.

2.8.1.2 Single-Mode Fibers in the Cable

Optical attenuation of each optical fiber in the cable (reeled) shall be 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. Measurement method shall be in accordance with TIA-455-78-B, at central wavelength 1300 nm nominal.

Pulse dispersion of each optical fiber in the cable (reeled) shall be no greater than 3.5 picosecond/nm-Km within the emissive region of 1285-1330 nm. Measurement method shall be in accordance with TIA-455-175.

Mode field diameter at 1300 nm optical spectrum window shall be within 10 plus or minus 1 micrometer. Measurement method shall be 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.

Cut-off wavelength for 1300 nm optical spectrum window shall be within 1200 plus or minus 70 nm. Measurement method shall be in accordance with ANSI/TIA-455-80C.

2.8.2 Mechanical Performance

2.8.2.1 Minimum Bend Radius

Cable shall be able to withstand 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.

2.8.2.2 Tensile Strength

Fiber optical cable shall withstand a pull force of at least [1800] newtons [(400 pounds)] [_____] to be applied to the pulling strength member during the installation, and a tensile load of at least [300] [_____] newtons during operation without incurring any damage or detriment to fiber optical cable and optical performance. Tensile strength test shall be in accordance with TIA-455-33.

2.8.2.3 Flexing or Bending Cycles

Fiber optical cable shall withstand at least [20] [_____] bending cycles at minimum bend radius without damage to the fiber optic cable components or degrading optical performance. Cyclic flexing test shall be in accordance with TIA-455-104.

2.8.2.4 Crush Resistance

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

2.8.2.5 Impact Resistance

Fiber optical cable shall be capable of withstanding [20] [_____] impacts,

at five newton-meters force, without damage to cable components, or degradation of optical performance. Impact resistance test shall be in accordance with TIA/EIA-455-25.

2.8.2.6 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.

2.8.2.7 Fluid Penetration

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

2.9 TEMPERATURE ENVIRONMENT

Fiber optical cable shall comply with the mechanical performance requirements herein while used in duct applications where the temperature varies from minus 8 degrees C to plus 38 degrees C. Optical performance degradation shall be less than [five] [_____] percent of the optical performance requirements in the temperature range of minus 20 degrees C to plus 60 degrees C. Do not damage fiber optical cable in storage where the temperature may vary from minus 40 degrees C to plus 65 degrees C.

2.10 SPLICE COMPATIBILITY TEST

When the material of the optic fiber is different from Cornings' Class Code No. 1517 for multi-mode graded index fiber and No. 1528 for single-mode fiber, perform and document the Splice Compatibility Test as follows:

Vendor shall select fiber samples from a minimum of [3] [_____] different production lots of the fiber type proposed for the job.

Vendor shall 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. 1517 and No. 1528, supplied by the Government.

Measure fusion splices using an Optical Time Domain Reflectometer (OTDR) operating in the region of 1250 through 1350 nm. The insertion loss of the fusion splice shall be 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. Vendor's fiber and the Corning fiber shall each be a minimum of 1 Km in length throughout the testing.

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.

Vendor shall be allowed 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.

2.11 FIBER OPTIC ENCLOSURES

Provide metallic enclosures for fiber optic data transmission equipment. NEMA 250, type 4 enclosure. Enclosures shall protect the spliced fibers from moisture and physical damage. Splice closure shall provide strain relief for the cable and the fibers at splice points. Provide full documentation citing conformance to structural parameters.

2.12 FIBER OPTIC TERMINATIONS AND CONNECTORS

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

2.13 FIBER OPTIC PATHWAY SYSTEM

Provide an FO pathway system including raceway conduit, duct system, and maintenance manholes and handholes as shown on the drawings. Pathway materials shall comply with TIA/EIA-569-A, 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.

2.13.1 Conduit

Conduit as specified in Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.14 FACTORY FO QUALITY CONTROL

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

2.15 PREPARATION FOR DELIVERY

Ship media on reels in [____] m [____] ft lengths. Provide 2 meters 6 1/2 feet pigtails on each end of media accessible for testing. Reel drum shall comply with manufacturers recommended bend radius for the media. Wind media on reel so that unreeling can be done without kinking the media. Attach a permanent waterproof label with indelible text on reel showing the length, media type, bandwidth, attenuation, and date of manufacture.

2.16 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 and EIA TIA/EIA-526-14A Method B for multi mode fiber measurements. Calibrate OTDR to show anomalies of 0.2 dB minimum. Provide digitized or photographic traces to the Contracting Officer.

2.17 MISCELLANEOUS ITEMS

2.17.1 FO Media Tags

Provide stainless steel, 41.25 mm 1 5/8 inches in diameter 1.58 mm 1/16 inch thick, and circular in shape.

2.17.2 Buried Warning and Identification Tape

Provide color, type and depth of tape as specified in paragraph "Buried Warning and Identification Tape" in Section 31 00 00 EARTHWORK, FO media must be marked and protected as required by TIA-590.

2.17.3 Grounding Braid

Grounding braid shall provide low electrical impedance connections for dependable shield bonding. Make braid from flat tin-plated copper.

PART 3 EXECUTION

3.1 FIBER SPLICES

Outside plant fiber splices shall be [fusion] [mechanical] type and made along the fiber route. Splices shall exhibit an insertion loss not greater than 0.2 dB. Make all splice measurements at 1300 nm, plus or minus 5 nm. Mount all splices in trays. Do not increase number of splices.

Cover completed splice with a protective sleeve heat shrink type to restore the protective properties of the fiber coating and buffering. Deviations to the splice, location and pulling plan will be permitted, upon approval by the Contracting Officer, and shall be provided at no additional cost to the Government.

All fiber colors shall be continuous from end to end. No switching or staggering of color scheme within the cable at splice points shall be allowed. Splice fibers in order with multi-mode fibers identified first and single mode fibers at the end.

Bring cables out of the manhole in a controlled environment to perform the fiber fusion splice operation. Complete splice by returning the cable to the manhole such that the excess cable does not impede future entrance and utilization. Secure cable at regular intervals.

3.2 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. All media which fail the factory or reel tests or final acceptance field tests shall be replaced and re-tested at the contractors expense. Splices are not permitted unless shown on the construction drawings. Field test splices within 24 hours after splice installation. Test splices to demonstrate a maximum 0.2 dB loss. Provide a splice box for each field splice. Provide a minimum of 2 meters for routing and testing media. Protect media ends of unspliced FO media during splicing operations.

3.2.1 Contractor Damage

Promptly repair indicated utility and communications lines or systems damaged during site preparation and construction. Damage to lines or systems not indicated, which are caused by contractor operations, shall be treated as "Changes" under the terms of the Contract clauses. When Contractor is advised in writing of the location of a non-indicated line or system, such notice shall provide 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.

3.3 BURIED CABLE INSTALLATION

3.3.1 Location

****
NOTE: Buried cable installation refers to the placement of cables directly in the ground without protection other than their own outer coverage (jackets). The overall buried cable installation may include manholes and hand holes, for splicing, terminating and pull-through purposes.
****

Location of the cable splice overlaps shall be as indicated. Contractor shall ensure that all cable ends are sufficiently long before cutting.

3.3.2 Field Staking

When staking the cable plow or trench line, place stakes at least every 30 meter 100 feet in level country and more frequently in rolling country or in dense vegetation, so that the construction force can sight at least two successive stakes at all times. Stakes should be placed at changes in direction, the beginning and end of all turns should be staked clearly. Where existing buried cable is encountered within [600] [_____] millimeter [2] [_____] feet of the proposed line, decrease the distance between stakes to a minimum of [3] [_____] meter [10] [_____] feet. When possible, stakes should project above the vegetation along the line. When a road or other crossings are involved, stakes should be placed at both extremes of the right-of-way.

A stake, with the appropriate number or explanation noted on it, should be used to show the location of each caution point, such as underground utility crossings and culverts; miscellaneous points, such as physical cable protection; and buried cable warning sign locations.

3.3.3 Method of Cable Placement

****
NOTE: Method used in placing the cable will depend on the exact location of the route, obstructions encountered, soil conditions, and topography of the route. Method which best suits the local conditions and which produces the least amount of disturbance or damage to existing utilities and surrounding areas should be used. Under certain conditions, combinations of placing methods may be advantageous.
****

All direct buried cable shall have a warning tape placed above it as indicated.

Depth of buried cable in soil measured from the top of the cable to the surface of the ground shall be a minimum of [800] [_____] millimeter [30] [_____] inches, when existing utilities are crossed, use hand excavation at a distance of no less than [1.3] [_____] meter [four] [_____] feet on each side of the utility.

3.3.3.1 Open Trench Method

Contractor shall observe the following when placing cable by the open trench method:

Trench shall be free of all rock and debris.

Pull cable from cable reel truck or dolly and place in the trench by hand.

Place cable in trench as soon as practical and backfilled immediately to avoid cave-in, and ensure safe operational conditions.

An inspector shall walk closely behind the cable reel dolly and ensure that the cable lies flat on the trench bottom, and is placed at the required minimum depth.

Pull cable by hand on each end simultaneously, to remove excess slack, prior to backfilling.

Backfill trench in [150] [_____] millimeter [six] [_____] inch lifts to ensure proper fill. Each backfill lift shall be compacted with hand tamp tools. First lift shall be hand tamped prior to placing the cable.

3.3.3.2 Direct Plow Method

Contractor shall observe the following when placing cable by the direct plow method:

Plow shall be clear of any obstruction which may damage cable and ensure that all rollers on the tractor and on the plow turn freely and are properly located.

Cable shall be hand fed off the reel at all times to ensure that no damage is done to the cable due to excess tension.

An inspector shall walk closely behind the plow and inspect the cable for any blemish or damage, and ensure a free and continuous flow of the cable from the reel to the plow. Inspector shall ensure that the cable is plowed at the minimum required depth.

3.3.4 Compaction

****

NOTE: The following method of compaction is recommended: Run the tractor track or tire along and immediately adjacent to both sides of the plow slot; fill in any ground depressions which may develop with earth to form a mound over the center of the plow slot; and then run the tractor tire over the center slot. Different soil conditions may warrant that other methods of compaction be employed.

****

Plow slot shall be compacted following the plowing in or trenching of wire or cable.

3.4 UNDERGROUND CABLE INSTALLATION

Inner duct assignment of individual cables shall be 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. Cable with dents, flat spots, or other sheath distortions shall not be installed.

3.4.1 Securing Cable

Immediately after cable placement, a permanent identification tag as indicated shall be attached 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, supports and fasteners shall be used to secure cables and equipment in position. Metallic supports and fasteners shall have a corrosion resistant finish. Rout all cables along the interior sides of manholes.

Two or more cable hooks shall be required per manhole.

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

3.4.2 Bending

Use caution when bending cable to avoid kinks or other damage to the sheath. Bend radius shall be as large as possible with a minimum of [250] [_____] millimeter [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.

3.4.3 Pulling

Attach pulling lines to both cable ends when cable is destined for bi-directional pull, and fitted with factory-installed pulling eyes. Cables not equipped with a pulling eye shall have the 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.

Rigging shall be set up 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.

3.4.4 Lubricant

Pulling lubricant, shall be used 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, the exposed cable ends shall be wiped clean of lubricant.

Lubricants shall be compatible with and intended for use with plastic-sheathed cables. Do not allow soap and grease type lubricants.

All equipment and the pulling set shall be checked 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, the tension of the pulling line shall not be released. When pulling is resumed, the inertia of the cable shall be overcome by increasing the tension in small steps a few seconds apart until the cable is in motion. Cable shall be paid from the top of the reel by rotating the reel in the feed direction at the rate of pull. Cable shall not be stripped off the reel by pulling.

3.4.5 Damage and Defects

Contractor shall 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, pulling shall stop immediately and the cable section shall be repaired or replaced 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 manhole 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. Cables in pull-through manholes shall be set up and racked before the cable ends in adjacent manholes are set up and racked.

Cable ends pulled into manholes, vaults, or terminal locations that are not to be racked or otherwise permanently positioned immediately shall be tied in fixed positions to prevent damage to the cables and provide adequate working space.

3.4.6 Seal

Ducts or innerduct in which cable is placed shall be sealed 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 manhole or vault.

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.

3.5 CABLE INSTALLATION IN CABLE TRAYS

Do not install communication cables in the same cable tray with ac power cables.

Cables placed in cable trays shall be installed in a neat and orderly manner and shall not cross or interlace other cables except at breakout points.

Individually retain cables in vertical trays with straps at a maximum of [1800] [_____] millimeter [6] [_____] feet on center.

3.6 GROUNDING SYSTEMS

Ground cables at each termination point or as indicated.

3.7 DIRECT BURIAL SYSTEM INSTALLATION

****
NOTE: Designer must specify the depth of media placement. Designer may specify air blown fiber installed in new or existing underground duct pending the approval of the media manufacturer. Air blown fiber installation and construction materials must be approved by the contracting officer.
****

Installation shall be in accordance with TIA-590. Under railroad tracks, paved areas, and roadways install cable in conduit encased in concrete. Slope ducts to drain. Excavate trenches by hand or mechanical trenching equipment. Provide a minimum cable cover of 610 mm 24 inches below finished grade. Trenches shall be not less than 155 mm 6 inches wide and in straight lines between cable markers. Do not use cable plows. Bends in trenches shall have a radius of not less than [915][_____] mm [36][_____] inches. Where two or more cables are laid parallel in the same trench, space laterally at least 75 mm 3 inches apart. When rock is encountered, remove it to a depth of at least 75 mm 3 inches below the cable and fill the space with sand or clean earth free from particles larger than 6 mm 1/4 inch. Do not unreel and pull cables into the trench from one end. Cable may be unreeled on grade and lifted into position. Provide color, type and depth of warning tape as specified in Section 31 00 00 EARTHWORK.

3.7.1 Media Placement

a. Separate FO media crossing other cables or metal piping from the other cables or pipe by not less than [75][_____] mm [3][_____] inches of well tamped earth. Do not install FO media under or above traffic signal loops.

b. Media shall be in one continuous length without splices except where splices are shown on the drawings.

c. Do not allow bends in media which exceed the manufacturers minimum recommended radii. Do not bend media to a radius less than 10 times the outside diameter of the media.

d. Leave a horizontal slack of approximately 915 mm 3 feet in the ground on each end of cable runs, on each side of connection boxes, and at points where connections are brought above ground. Where cable is brought above ground, leave additional slack to make necessary connections.

3.7.2 Identification Slabs (Markers)

Provide a marker at each change of direction of the cable, over the ends of ducts or conduits which are installed under paved areas and roadways and over each splice. Identification markers shall be of concrete, approximately500 mm 20 inches square by 150 mm 6 inches thick and stake mounted warnings meeting the requirements of REA.

3.8 UNDERGROUND DUCT INSTALLATION

Construct underground duct as specified in Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION. Encase in concrete any ducts under roads, paved areas, or railroad tracks.

3.8.1 Connections to Existing Maintenance Holes [and Handholes]

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.

3.8.2 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.

3.8.3 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.

3.9 RECONDITIONING OF SURFACES INSTALLATION

3.9.1 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.

3.9.2 Paving Repairs

****
NOTE: Choose one of the following options.
****

[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. Surface treatment or pavement shall also match and tie into the adjacent and surrounding existing

surfaces.]

****

NOTE: Insert appropriate Section number and title in the blank below using format per UFC 1-300-02 UNIFIED FACILITIES GUIDE SPECIFICATIONS (UFGS) FORMAT STANDARD.

****

[b. Make paving repairs as specified in [_____].]

3.10 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. Under no circumstances shall the media be paid 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 paid off the reel. As media is paid 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 pay off freely. Rectify cause of binding before resuming pulling operations. Provide media lubricants recommended by the cable manufacturer. Provide 1 meter 3.3 feet of spare media in all manholes and enclosures for final termination and testing.

3.10.1 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.

3.10.2 Pulling Eyes

Equip media 30 mm 1-1/4 inches in diameter and larger with cable manufacturer's factory installed pulling-in eyes. Provide media with diameter smaller than 30 mm 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 19 mm 3/4 inch links between pulling-in eyes or grips and pulling strand.

3.10.3 Installation of 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, and support media on brackets and cable insulators at a maximum of 1220 mm 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.

3.11 AERIAL MEDIA INSTALLATION

****
NOTE: Include tensioning and sag data on drawings in tabular form.
****

Pole installation shall be as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION. Where physical obstructions make it necessary to pull distribution wire along the line from a stationary reel, use cable stringing blocks to support wire during placing and tensioning operations. Do not place ladders, cable coils, and other equipment on or against the distribution wire. Wire shall be sagged in accordance with the data shown.

3.11.1 Aerial FO Media

Keep media ends sealed at all times using cable end caps. Take media from reel only as it is placed. During placing operations, do not bend in a radius less than 10 times the outside diameter of media. Place temporary supports sufficiently close together, and properly tension the media where necessary, to prevent excessive bending. In those instances where spiraling of media is involved, accomplish mounting of enclosures for purposes of loading, splicing, and distribution after the spiraling operation has been completed.

3.12 Grounding

****
NOTE: Designer should verify the existence of grounding facilities. It is essential that all grounding facilities, new and existing, conform with IEEE C2, NFPA 70, MIL-HDBK-419, and MIL-STD-188-124.
****

Ground exposed non current carrying metallic parts of telephone equipment, media sheaths, media splices, and terminals.

3.13 Housekeeping

The Contractor shall be responsible for cleaning up work area and maintaining the work area in orderly condition.

3.14 CABLE DELIVERY

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

3.15 TESTING

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

All test equipment, test procedures, and testing techniques shall be specified in the quality assurance plan and will require approval prior to execution. Tests shall be conducted by the Contractor in accordance with the approved Quality Assurance Plan. Field tests shall be witnessed by the Contracting Officer. Contracting Officer shall be given at least [20][_____] calendar days notice prior to performing each test.

Each test sheet shall have a sign-off blank for the Contractor as well as the Contracting Officer. Deliver copies of the completed test forms and test results as indicated.

Sequential cable markings along the cable, prior to and after each end of splice point, shall be recorded on the sequential cable form and submitted for approval.

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

Contractor shall maintain an accurate test record during all field tests.

3.15.1 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 certified test results shall accompany the media. Perform OTDR tests with media on reels and compare factory and field test data.

****

NOTE: The purpose of this test is to assure the Government and the installation contractor that the media was not damaged during shipment.

****

3.15.1.1 Reel Test Results

Provide results of reel tests to the Contracting Officer at least [5][____] working days before installation is to commence. Results shall indicate reel number of the media, manufacturer, type and number of fiber tested, and recorded readings. When reel tests indicate that the media does not comply with factory reel test results remove the media from the job site and replace with compliant media.

3.15.2 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). Test multi mode fiber in accordance with TIA-526-14(Optical Power Loss).

3.15.2.1 Test Results

Provide results of final acceptance tests (attenuation tests, OTDR traces, etc.), to the Contracting Officer at least [5][_____] working days after completion of tests.

3.16 TEST REQUIREMENTS

Test equipment used for verifying installation testing shall be calibrated by a certified testing company within [3] [_____] weeks of use.

3.16.1 Single and Multi-mode OTDR Test

The Optical Time Domain Reflectometer (OTDR) shall conform to the following minimum requirements:

Operating wavelengths: [1,300] [_____] plus or minus 20 nanometers

Attenuation Range (one way): minimum [15] [_____] dB at 1,300 nm

Attenuation Resolution: [0.01] [_____] dB

Accuracy: plus [0.5] [_____] dB.

OTDRs shall have digital readout capability and shall have a means of providing a permanent record in the form of a [strip chart] [photograph] [_____].

3.16.2 End-to-End Attenuation Tests

An attenuation measurement test set shall consist of an optical power meter and an optical power source. Attenuation measurement test set shall be 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. Measurement test set shall conform to the following minimum requirements:

Operating wavelengths: [1,300] [_____] plus or minus 10 nanometers

Attenuation Range: at least [30] [_____] dB at 1,300 nm

Attenuation Resolution: [0.01] [_____] dB

Accuracy: The accuracy of the attenuation measurement test set shall be plus or minus [5] [_____] percent.

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

3.16.3 End-to-End Bandwidth Tests

Bandwidth test shall conform to the following minimum requirements:

Operating wavelengths: [1,300] [_____] plus or minus 10 nanometers

Bandwidth range: minimum [1000] [_____] megahertz

Bandwidth Resolution: [1] [_____] megahertz

Accuracy: plus or minus [0.5] [_____] megahertz

Measurement Method: [Swept Frequency] [_____]

-- End of Section --