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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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SECTION TABLE OF CONTENTS

DIVISION 27 - COMMUNICATIONS

SECTION 27 21 10.00 40

FIBER OPTIC DATA TRANSMISSION SYSTEM

11/20

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 MAINTENANCE MATERIAL SUBMITTALS
1.3.1 Spare Parts

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION
2.1.1 Environmental Requirements
2.1.2 Hazardous Environment
2.1.3 Electrical Requirements
2.1.4 Input Line Surge Protection
2.1.5 Power Line Surge Protection
2.2 COMPONENTS
2.2.1 FO Modems
2.2.1.1 FO Modem Operating Wavelength
2.2.1.2 FO Modem Inputs and Outputs
2.2.2 FO Transmitter And Receiver Modules
2.2.2.1 Analog FO Transmitter and Receiver Modules
2.2.2.2 Digital FO Transmitter and Receiver Modules
2.2.2.3 FO Transmitter Module
2.2.2.4 FO Receiver Module
2.2.3 FO Digital Repeaters
2.2.4 FO Analog Repeaters
2.2.5 Transceivers for Video Applications
2.2.6 Transceivers for Lan Applications
2.2.7 FO Switches
2.2.8 FO Splitter/Combiner
2.2.9 Fiber Optic Digital Repeaters (FODR)
2.2.10 Data Transmission Converter
2.2.11 Enclosures
2.2.11.1 Interior

2.2.11.2 Exterior
2.2.11.3 Corrosive Environment
2.2.11.4 Hazardous Environment
2.2.12 Tamper and Physical Protection Provisions
2.2.12.1 Enclosure Covers
2.2.12.2 Conduit-Enclosure Connections
2.2.12.3 Locks and Key-Lock-Operated Switches
2.2.13 Optical Fibers
2.2.13.1 General
2.2.13.2 50 Micron Multimode Fibers
2.2.13.3 62.5 Micron Multimode Fibers
2.2.13.4 8.3 Micron Single-Mode Fibers
2.2.14 Cross-Connects
2.2.14.1 Patch Panels
2.2.14.2 Patch Cords
2.3 SYSTEM REQUIREMENTS
2.3.1 Signal Transmission Code Format
2.3.2 Flux Budget/Gain Margin
2.3.3 Receiver Dynamic Range
2.4 ACCESSORIES
2.4.1 FO Connectors
2.4.2 Mechanical Splices
2.4.3 Fusion Splices
2.4.4 Conduit, Fittings And Enclosures
2.4.5 Fan-Out Kits
2.5 CABLE CONSTRUCTION
2.5.1 General
2.5.2 Exterior Cable
2.5.2.1 Aerial Cable
2.5.2.2 Duct Cable
2.5.2.3 Direct Burial Cable
2.5.3 Interior Cable
2.5.4 Pigtail Cables

PART 3 EXECUTION

3.1 INSTALLATION
3.1.1 Interior Work
3.1.2 Exterior Work, Aerial
3.1.3 Exterior Work Underground
3.1.4 Service Loops
3.1.5 Metallic Sheath Grounding
3.1.6 Splices
3.1.6.1 General
3.1.6.2 Mechanical Splices
3.1.7 Connectors
3.1.8 Identification and Labeling
3.1.9 Enclosure Sizing and Cable
3.1.10 Enclosure Penetrations
3.2 FIELD QUALITY CONTROL
3.2.1 General
3.2.2 Field Test
3.2.2.1 Optical Time Domain Reflectometer Tests
3.2.2.2 Power Attenuation Test
3.2.2.3 Gain Margin Test
3.2.2.4 Analog Video Signal Test
3.2.2.5 Digital Video Signal Test
3.2.2.6 Performance Verification Test and Endurance Test
3.3 CLOSEOUT ACTIVITIES

3.3.1 Delivery of Technical Data
3.3.1.1 Group I Technical Data Package
3.3.1.1.1 System Drawings
3.3.1.1.2 Equipment Data
3.3.1.1.3 Data Transmission System Description and Analyses
3.3.1.1.4 System Overall Reliability Calculations
3.3.1.1.5 Certifications
3.3.1.1.6 Key Control Plan
3.3.1.2 Group II Technical Data Package
3.3.1.3 Group III Technical Data Package
3.3.1.4 Group IV Technical Data Package
3.3.1.4.1 Performance Verification and Endurance Testing Data
3.3.1.4.2 Operation and Maintenance Data
3.3.1.4.3 Training Data
3.3.1.5 Group V Technical Data Package
3.3.1.5.1 Functional Design Manual
3.3.1.5.2 Hardware Manual
3.3.1.5.3 Maintenance Manual
3.3.1.5.4 Operator's Manual
3.3.1.6 Group VI Technical Data Package
3.3.2 Training
3.3.2.1 System Maintenance Training Course

-- End of Section Table of Contents --

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
****

SECTION 27 21 10.00 40

FIBER OPTIC DATA TRANSMISSION SYSTEM
11/20

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NOTE: This guide specification covers the requirements for fiber optics data transmission 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 item(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

****
NOTE: There are two ways the designer can require the submission of data concerning fiber optic equipment. The most common way is through the use of submittals. However, the Federal Acquisition Regulations apply special constraints on some types of technical data that fall under the Data Requirements Clause. Generally, the technical data associated with fiber optic data transmission systems do not fall under the special Data Requirements Clause. However, if other systems such as EMCS, UMCS, IDS, ESS, and CCTV, interconnected by FO systems do fall within the special category, the associated FO technical data should be acquired in the same manner. Therefore, if some systems used

with this specification fall under the special Data Requirements Clause, use sub-paragraph a. below for guidance.

a. The acquisition of all technical data, data bases and computer software items that are identified herein will be accomplished strictly in accordance with the Federal Acquisition Regulation (FAR) and the Department of Defense Federal Acquisition Regulation Supplement (DOD FARS). Those regulations, as well as the Army and ArmyCorps of Engineers implementations thereof, should also be consulted to ensure that a delivery of critical items of technical data is not inadvertently lost. Specifically, the Rights in Technical Data Non-commercial, DOD FARS 52.227-7013, and DOD FARS 52.227-7031 [Reserved], as well as any requisite software licensing agreements will be made a part of the CONTRACT CLAUSES or SPECIAL CONTRACT REQUIREMENTS of the contract. In addition, the appropriate DD Form 1423, Contract Data Requirements List, will be filled out for each distinct deliverable item and made a part of the contract. Where necessary, a DD Form 1664, Data Item Description, shall be used to explain and more fully identify the data items listed on the DD Form 1423. It is to be noted that all of these clauses and forms are required to assure the delivery of the data in question and that such data is obtained with the requisite rights to use by the Government. Include with the request for proposals a completed DD Form 1423, Contract Data Requirements List. This form is essential to obtain delivery of all documentation. Each deliverable will be clearly specified, both description and quantity being required.

****

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 Reference Identifier (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.

****

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.

ELECTRONIC COMPONENTS INDUSTRY ASSOCIATION (ECIA)

ECIA EIA/ECA 310-E	(2005) Cabinets, Racks, Panels, and Associated Equipment

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2023) National Electrical Safety Code
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-232	(1997f; R 2012) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
TIA-455-13	(1996a; R 2012) FOTP-13 Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies
TIA-455-58	(2001b) FOTP-58 Core Diameter Measurement of Graded-Index Optical Fibers
TIA-455-78-B	(2020c) FOTP-78 Optical Fibres - Part 1-40: Measurement Methods and Test Procedures - Attenuation
TIA-455-82	(2020c) FOTP-82 Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable

TIA-455-91	(1986; R 1996) FOTP-91 Fiber Optic Cable Twist-Bend Test
TIA-455-104	(2016b) Standard for FOTP-104 Fiber Optic Cable Cyclic Flexing Test
TIA-455-177	(2020c) FOTP-177 IEC-60793-1-43: Measurement Methods and Test Procedures - Numerical Aperture
TIA-485	(1998a; R 2012) Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems
TIA-606	(2021d) Administration Standard for Telecommunications Infrastructure
TIA/EIA-455-25	(2016d) FOTP-25 Impact Testing of Optical Fiber Cables
TIA/EIA-455-41	(1993a; R 2013) FOTP-41 Compressive Loading Resistance of Fiber Optic Cables
TIA/EIA-455-81	(2000b) FOTP-81 Compound Flow (Drip) Test for Filled Fiber Optic Cable
TIA/EIA-455-88	(2001) FOTP-88 Fiber Optic Cable Bend Test
TIA/EIA-455-171	(2001a) FOTP-171 - Attenuation by Substitution Measurement for Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies
TIA/EIA-455-204	(2000) Standard for Measurement of Bandwidth on Multimode Fiber

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

47 CFR 15	Radio Frequency Devices

UNDERWRITERS LABORATORIES (UL)

UL 1666	(2007; Reprint Sep 2021) UL Standard for Safety Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts

1.2 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified 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 Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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

****

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

SD-02 Shop Drawings

Fiber Optic System; G[, [____]]

Installation; G[, [____]]

SD-03 Product Data

Fiber Optic System; G[, [____]]

Spare Parts; G[, [____]]

Enclosures; G[, [____]]

Data Transmission Converters; G[, [____]]

SD-06 Test Reports

Test Procedures and Reports

Power Attenuation Test

Analog Video Signal Test

Digital Video Signal Test

Optical Time Domain Reflectometer Tests

SD-07 Certificates

Fiber Optic System

Optic Cable Assemblies

Labeling Format

SD-08 Manufacturer's Instructions

Manufacturer's Instructions

Manufacturer's Recommendations

SD-10 Operation and Maintenance Data

Operating Instructions

1.3 MAINTENANCE MATERIAL SUBMITTALS

1.3.1 Spare Parts

Submit spare parts data for each different item of material and equipment specified and furnished, after approval of detail drawings not later than [_____] months prior to the date of beneficial occupancy. Include a list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after [1 year] [3 years] of service.

PART 2 PRODUCTS

****

NOTE: All of the products listed in this section may not be required for every project. Keep the products required and delete the others.

****

2.1 SYSTEM DESCRIPTION

****

NOTE: Show on drawings the data transmission media required between each sub-assembly of the system or systems to be interconnected. Give consideration to compliance with NEC for supports, raceways, etc.

****

Provide a fiber optics (FO) data transmission system (DTS). The data transmission system consists of FO transmission media, transmitter and receiver modules, modems, transceiver modules, repeaters, cable and power line surge protection, terminal devices (such as connectors, patch panels and breakout boxes) and power supplies for operating active components. Interconnect the data transmission system system components as shown. Certify that computing devices comply with the requirements for Class A computing devices and are labeled as set forth in 47 CFR 15.

2.1.1 Environmental Requirements

****
NOTE: Select equipment and cable temperature rating within ambient temperature conditions at project location. State additional requirements when ambient conditions are more extreme than manufacturers' equipment ratings (e.g., conformal coating for 100 percent relative humidity or condensing atmospheres, enclosure heaters or enclosure coolers.)
****

Rate equipment and cable used indoors for continuous operation under ambient environmental conditions of 0 to 50 degrees C 32 to 122 degrees F dry bulb and 10 to 95 percent relative humidity, non-condensing. Rate equipment and cables for continuous outdoor operation under ambient environmental conditions of [minus 40] [minus [_____]] to plus [75] [_____] degrees C [minus 40] [minus [_____]] to plus [166] [_____] and humidity of up to 100 percent condensing or as normally encountered for the installed location. Rate all equipment and cable for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location. Install cables in ducts, plenums, and other air-handling spaces per NFPA 70. Ensure cables installed in plenums are plenum-rated cables listed for the use. Ensure cables installed in risers are riser-rated cables listed for the use, unless the installed cable is identified as a permitted substitution for the required riser-rated cable type.

2.1.2 Hazardous Environment

****
NOTE: Show hazardous (classified) environment area(s), type of hazard(s), and hazard classification (Class I, II, or III, or combinations; Divisions 1 or 2; Groups A, B, C, D, E, F, or G or combinations; and operating temperatures) on the drawings. Whenever possible, avoid placement of the FO DTS equipment and cables within the hazardous location to reduce installation costs, and to simplify maintenance.
****

Rate the system components and wiring located in areas where fire or explosion hazards may exist with the proper Classes, Divisions, and Groups. Also rate the components and wiring for the operating temperatures. Install according to Chapter 5 of NFPA 70 and as shown.

2.1.3 Electrical Requirements

Operate the equipment from a voltage source as shown, plus or minus 10 percent, and 60 Hz, plus or minus 2 percent.

2.1.4 Input Line Surge Protection

Protect inputs and outputs against surges induced on wiring and cables including wiring and cables installed outdoors. For components requiring protection, select surge protection devices based on voltages and current

ratings of components to be protected. Protect communications equipment against surges induced on any communications circuit. Install surge protection circuits at each end of cables and conductors (except non-conductive FO cables which serve as communications circuits from consoles to field equipment and between field equipment). Furnish protection at equipment. Install additional triple electrode gas surge protectors rated for the application on each conductive wire line and coaxial circuit within 1 meter 3-feet of the building cable entrance. Do not use fuses for surge protection. Test the inputs and outputs in both normal mode and common mode using the following two waveforms:

a. A 10 microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond rise time by 20 microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

2.1.5 Power Line Surge Protection

Protect equipment connected to AC circuits from power line surges. Select surge protection devices based on voltages and current ratings of components to be protected. Provide equipment that meets the requirements of IEEE C62.41.1 and IEEE C62.41.2. Do not use fuses for surge protection.

2.2 COMPONENTS

2.2.1 FO Modems

Select FO modems to meet FO system requirements. Ensure the modems allow full duplex, asynchronous, point-to-point digital communication for the system being installed.

2.2.1.1 FO Modem Operating Wavelength

****

NOTE: Select the required operating wavelength: Typically 850 and 1300 wavelengths are used with multimode fibers and 1300 and 1550 wavelengths are used with single-mode fibers. Generally, longer wavelengths should be used for cable lengths over 3 km (1.75 miles) because longer wavelengths exhibit less attenuation than shorter wavelengths. Dense Wave Division Multiplexing (DWDM) and Coarse Wave Division Multiplexing (CWDM) transmitters use multiple wavelengths; the flux budget should be based on the wavelength with the greatest attenuation.

****

Center the operating wavelength on [850] [1300] [1550] nanometers (nm).

2.2.1.2 FO Modem Inputs and Outputs

****

NOTE: Match the input and output configurations to the equipment to be interconnected. Make sure data rate of the FO modem exceeds the data rate of the devices served.

****

Provide FO modems that accept inputs and provide outputs compatible with [TIA-232] [TIA-485] [20 mA current loop] [T1] [10 Base-F]. Digital data rates through each link are [9.6 KBPS] [19.2 KBPS] [38.4 KBPS] [1.54 MBPS] [10 MBPS].

2.2.2 FO Transmitter And Receiver Modules

****

NOTE: There are several ways fiber optic transmitters and receivers can be implemented such as:

a. The transmitter and receiver can be mounted on a logic board. The transmitter and receiver are then an integral part of the system at the logic level.

b. The transmitter and receiver can be individual modules which are mounted external to the logic boards. They can be powered by their own power supplies and can communicate with the serial data ports of the logic boards at logic levels.

c. The fiber optics transmitter and receiver can be combined with interface and control logic to form a fiber optic modem. The system field equipment can thus communicate with the modem over a EIA 232-F serial data port.

Determine where FO communication devices are located. In many systems, FO transmitters and receivers or modems are located in the field equipment enclosures of the systems being supported by the FO system. Often, these FO devices are physically mounted on circuit cards or modules. In other cases, FO devices are installed in separate enclosures provided with the FO system. This is often the case for FO repeaters and active star units.

****

Ensure FO transmitter/receiver pairs have signal-to-noise power ratio of 40 dB or better after photo detection at the receiver. Transmitter power output and receiver sensitivity cannot drift more than plus or minus 2 dB over their operational life.

2.2.2.1 Analog FO Transmitter and Receiver Modules

Ensure FO transmitter/receiver pairs used to pass analog video signals accept inputs and provide outputs that have a bandwidth of 6 MHz or greater.

2.2.2.2 Digital FO Transmitter and Receiver Modules

Ensure FO transmitter/receiver pairs used to pass digital signals accept inputs and provide outputs compatible with [TIA-232] [TIA-485] [20 mA current loop] [T1] [10 Base-F]. Digital data rates through each link are [9.6 KBPS] [19.2 KBPS] [38.4 KBPS] [1.54 MBPS] [10 MBPS]. House FO transmitter and receiver modules [in field equipment enclosures where

possible] [in new enclosures] [as shown]. Provide FO transmitter and receiver modules compatible with each other, the FO cable, and connectors.

2.2.2.3 FO Transmitter Module

Provide a FO transmitter module that accepts electronic signals and modulates a light source. Couple the light source into an FO cable. Center the operating wavelength on [850] [1300] [1550] [850 and 1300] [1300 and 1550] nanometers.

2.2.2.4 FO Receiver Module

Ensure the FO receiver module receives light from the FO cable and converts this light into an electronic signal identical to the electronic signal applied to the FO transmitter module. Ensure the operating wavelength is the same as the transmitter.

2.2.3 FO Digital Repeaters

Use FO digital repeaters to extend the range of the FO data transmission system when necessary to meet the requirements of paragraph SYSTEM REQUIREMENTS. For simplex circuits, the repeater consists of an FO receiver connected to an FO transmitter. For Duplex circuits, the repeater consists of a pair of FO receivers that are connected to a pair of FO transmitters. The FO receivers receive the optical signal and drive the transmitters. The transmitters regenerate the optical signal at the transmission rate specified. Ensure the FO repeater is mechanically and optically compatible with the remainder of the FO system.

2.2.4 FO Analog Repeaters

Use FO analog repeaters to extend the range of the FO data transmission system when necessary to meet the requirements of paragraph SYSTEM REQUIREMENTS. For simplex circuits, the repeater consists of an FO receiver connected to an FO transmitter. For duplex circuits, the repeater consists of a pair of FO receivers that are connected to a pair of FO transmitters. The FO receivers receives the optical signal and drive the transmitters. Ensure the FO repeater is mechanically and optically compatible with the remainder of the FO system.

2.2.5 Transceivers for Video Applications

Provide FO Transceivers that allow bi-directional signal transmission on a single fiber. The operating wavelength in one direction is 1300/850 nanometers, while in the opposite direction, 850/1300 nanometers. Crosstalk attenuation between channels is 40 dB or greater. Select FO transceivers to match or exceed the highest data rate of attached input devices. Ensure the FO transceiver is mechanically and optically compatible with the remainder of the FO system.

2.2.6 Transceivers for Lan Applications

****

NOTE: Use the transceivers for ESS or UMCS systems which use a LAN topology for communication.

****

Provide transceivers for FO LAN applications that are active units, and compatible with the LAN cards, modems and repeaters used in the system.

Provide indicators for power, collision detection, receive, transmit, and status. Derive power for transceivers from the Attachment Unit Interface (AUI) port of LAN equipment or from a dedicated power supply. Ensure transceiver loss characteristics are less than 1.0 db. Provide low loss connectors that are compatible with LAN equipment. Include circuitry so when a device is disconnected, other devices on the LAN continue to operate without any disruption.

2.2.7 FO Switches

****

NOTE: Show FO switches and designate latching or nonlatching on contract drawings.

****

Provide single pole, double throw FO switches with switching speed less than 15 milliseconds, and insertion loss less than 1.5 dB. Provide crosstalk attenuation between FO outputs at 40 dB or greater. FO switches are latching or nonlatching, as shown.

2.2.8 FO Splitter/Combiner

For FO splitter/combiner units, provide full-duplex communications in a multi-point configuration. Ensure each unit has one input port module and up to four output port modules. Ensure FO splitter/combiner units are mechanically and optically compatible with the remainder of the FO system. The splitter/combiner allows a mixed configuration of port module operating wavelengths and single-mode or multimode FO cables. Ensure each port module has a separate FO cable input and output. Connect port modules using an electronic data bus. Port module FO transmitters regenerate the optical signal at the transmission rate specified. Rack mount port modules in a 483 mm 19-inch rack complying with ECIA EIA/ECA 310-E. Ensure the total propagation delay through the splitter/combiner is less than 100 nanoseconds.

2.2.9 Fiber Optic Digital Repeaters (FODR)

FODRs combine the features specified for Fiber Optic Digital Repeaters and Local Area Network (LAN) transceivers. FODRs regenerate the optical signal at the transmission rate specified. Ensure the FODRs are mechanically and optically compatible with the remainder of the Fiber Optic System. Ensure FODRs restore the optical signals amplitude, timing and waveform and provide an electrical interface to the transmission media. Ensure the electrical interface is identical to all other network interfaces as specified.

Submit a manufacturer's certificate of the Fiber Optic System indicating compliance with transmission and reliability requirements. Where equipment or materials are specified to conform to the standards or publications and requirements of CFR, ANSI,IEEE, NEMA, NFPA, EIA, or UL, furnish certificates attesting that the items identified conform to the specified requirements.

2.2.10 Data Transmission Converter

Use data transmission converters to connect equipment using TIA-485 data transmission when necessary and as shown. Install converters that operate full duplex and support two wire circuits at speeds up to 2 megabytes per second and have a built in 120 Ohm terminating resistor. Ensure

converters are mechanically, electrically, and optically compatible with the system.

2.2.11 Enclosures

****

NOTE: If all FO devices are located in enclosures of other systems, the paragraph ENCLOSURES can be deleted. Otherwise, paragraph ENCLOSURES remain and enclosure locations are shown on the drawings.

****

Ensure enclosures conform to the requirements of NEMA 250 for the types specified. Use the manufacturer's standard finish color, unless otherwise indicated. Repair and refinish damaged surfaces using original type finish.

2.2.11.1 Interior

Ensure the enclosures installed indoors meet the requirements of NEMA 250 Type 12 or as shown.

2.2.11.2 Exterior

****

NOTE: For exterior applications where corrosive environments exist, specify Type 4X. Type 4X metallic enclosures should be used for security applications where physical hardening is required.

****

Ensure enclosures installed outdoors meet the requirements of NEMA 250 Type 4 unless otherwise specified or shown.

2.2.11.3 Corrosive Environment

****

NOTE: Show corrosive locations on the drawings.

****

For enclosures in a corrosive environment, meet the requirements of NEMA 250, Type 4X.

2.2.11.4 Hazardous Environment

For enclosures installed in a hazardous environment, meet the requirements as specified in paragraph ENVIRONMENTAL REQUIREMENTS.

2.2.12 Tamper and Physical Protection Provisions

****

NOTE: Tamper and physical protection provisions are only required for FO system applications involving security systems such as IDS, ESS or CCTV. This requirement should be deleted for all other applications. Generally, security screws are preferred over tack welding or brazing because the enclosure surface protection is not damaged.

****

Provide enclosures and fittings of every description having hinged doors or removable covers that contain the FO circuits, connections, splices, or power supplies, with cover-operated, corrosion-resistant tamper switches, arranged to initiate an alarm signal when the door or cover is moved. Mechanically mount tamper switches to maximize the defeat time when enclosure covers are opened or removed. Ensure the enclosure and the tamper switch function together to not allow direct line of sight to any internal components and tampering with the switch or the circuits before the switch activates.

Ensure tamper switches are inaccessible until the switch is activated; have mounting hardware concealed so that the location of the switch cannot be observed from the exterior of the enclosure; are connected to circuits which are under electrical supervision at all times, irrespective of the protection mode in which the circuit is operating; are spring-loaded and held in the closed position by the door cover; and are wired so that they break the circuit when the door or cover is disturbed.

Ensure tamper switches located in enclosures which open to make routine maintenance adjustments to the system and to service the power supplies are push/pull-set, automatic reset type.

2.2.12.1 Enclosure Covers

Covers of pull and junction boxes provided to facilitate installation of the system need not be provided with tamper switches if they contain no splices, connections or power supplies, but are protected by [security screws] [tack welding or brazing] to hold the covers in place. Affix zinc labels to such boxes indicating they contain no connections. Do not indicate with these labels that the box is part of a security system. Clean and repair damage to the enclosure or its cover's surface protection using the same type of surface protection as the original enclosure. Secure the conduit enclosures constructed of fiberglass with tamper proof security servers.

2.2.12.2 Conduit-Enclosure Connections

****

NOTE: Tamper and physical protection provisions are only required for FO system applications involving security systems such as IDS, ESS, or CCTV. Delete this requirement for all other applications.

****

Protect conduit enclosure connections by tack welding or brazing the conduit to the enclosure. Apply tack welding or brazing in addition to standard conduit-enclosure connection methods as described in NFPA 70. Clean and repair any damage to the enclosure or its cover's surface protection using the same type of surface protection as the original enclosure. Secure conduit enclosures constructed of fiberglass with tamper proof security screws.

2.2.12.3 Locks and Key-Lock-Operated Switches

****

NOTE: Either round key or conventional key type locks as defined in this specification are acceptable. Selection should be based on hardware

availability at the time of design and the requirement for matching locks currently in use at the site. If the locks do not have to be matched to locks in use at the site, and the designer has no preference as to lock type, all brackets may be removed.

****

a. Locks

When locks are required, install UL listed locks on system enclosures for maintenance purposes, [round key type, with three dual, one mushroom, and three plain pin tumblers] [or] [conventional key type lock having a combination of five cylinder pin and five-point three position side bar]. Stamp keys U.S. GOVT. DO NOT DUP. Arrange the locks so that the key can only be withdrawn when in the locked position. Key all maintenance locks alike and furnish only two keys for all of these locks.

b. Key-Lock-Operated Switches

Install UL listed key-lock-operated switches when locks are required to be installed on system components, [with three dual, one mushroom, and three plain pin tumblers,] [or] [conventional key type lock having a combination of five cylinder pin and five-point three position side bar]. Stamp keys U.S. GOVT. DO NOT DUP. Provide two position key-lock-operated switches, with the key removable in either position. Key all key-lock-operated switches differently and furnish only two keys for each key-lock-operated switch.

2.2.13 Optical Fibers

****

NOTE: FO systems use one or two fibers for each full duplex FO link. In the two-fiber links data flows only in one direction in each fiber. DWM and CWM systems often use one fiber for each full duplex FO link in which differing wavelengths travel in opposite directions on one fiber. In some cases, such as sending sync and receiving video from long distances, bi-directional transmission on one fiber is desired. Shorter wavelengths generally have greater attenuation; loss budgets should be based on the wavelength with the greater attenuation.

****

2.2.13.1 General

Coat optical fibers with a suitable material to preserve the intrinsic strength of the glass. The outside diameter of the glass-cladded fiber is nominally 125 microns, and concentric with the fiber core. Ensure optical fibers meet TIA-455-78-B, and TIA-455-177.

2.2.13.2 50 Micron Multimode Fibers

Use conductors that are multimode, graded index, solid glass waveguides with a nominal core diameter of 50 microns. Ensure the fiber has transmission windows centered at 850 and 1300 nanometer wavelengths, with a numerical aperture minimum of 0.20. The attenuation at 850 nanometers is 3.5 dB/Km or less. The attenuation at 1300 nanometers is 1.5 dB/Km or

less. For both transmission windows, the minimum bandwidth is 500 MHz-Km. Certify the fibers to meet TIA/EIA-455-204 and TIA-455-58.

2.2.13.3 62.5 Micron Multimode Fibers

Use conductors that are multimode, graded index, solid glass waveguides with a nominal core diameter of 62.5 microns. Ensure the fiber has transmission windows centered at 850 and 1300 nanometer wavelengths, with a numerical aperture minimum of 0.275. The attenuation at 850 nanometers is 3.5 dB/Km or less. The attenuation at 1300 nanometers is 1.5 dB/Km or less. The minimum bandwidth is 160 MHz-Km at 850 nanometers and 500 MHz-Km at 1300 nanometers. Certify FO cable to meet TIA/EIA-455-204 and TIA-455-58.

2.2.13.4 8.3 Micron Single-Mode Fibers

****

NOTE: Single-mode FO DTS offer larger bandwidth, and less attenuation, usually at greater system cost than multimode FO DTS. Only use single-mode FO DTS when the designer determines that large bandwidth or low attenuation links warrant the single-mode FO DTS.

****

Use conductors that are single-mode, solid glass waveguides with a nominal core diameter of 8.3 microns. Ensure the fiber has a transmission windows centered at 1310 and 1550 nanometer wavelengths with a numerical aperture minimum of 0.10. The attenuation for inside cable at 1310 and 1550 nanometers is 1.0 dB/Km or less. The attenuation for outside cable at 1310 and 1550 nanometers is 0.5 dB/Km or less. Certify the fibers to meet ANSI/TIA-455-80C.

2.2.14 Cross-Connects

2.2.14.1 Patch Panels

****

NOTE: Show cross-connect or interconnect configuration on the drawings.

****

Install patch panels as a complete system of components by a single manufacturer; provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Ensure patch panel connectors and couplers are the same type and configuration as used elsewhere in the system. Patch panels are [a 480 mm 19-inch rack mount type] [wall mounted] [as shown].

2.2.14.2 Patch Cords

Provide patch cord cable assemblies consisting of factory connector-terminated flexible optical fiber cable with connectors of the same type as used elsewhere in the system. Optical fiber is the same type as used elsewhere in the system. Install patch cords as complete assemblies from manufacturer's standard products.

2.3 SYSTEM REQUIREMENTS

2.3.1 Signal Transmission Code Format

****

NOTE: Different FO systems may use different modulation methods and codes. For example, the digital signal may turn the light source on or off, it may use frequency shift keying, or it may cause the intensity to shift between two preset levels. Likewise, the code can be the simple NRZ (non-return to zero), or it can be the more complex and efficient RZ (return to zero) code, such as the Manchester code. The modulation method can be important to bandwidth limited systems since some methods required twice the bandwidth of other methods for transmitting the same data.

****

Ensure FO equipment uses the same transmission code format from the beginning of a circuit to the end of that circuit. Different transmission code formats may be used for different circuits as required to interconnect supported equipment.

2.3.2 Flux Budget/Gain Margin

****

NOTE: The flux budget calculations for each FO link are used to determine if the gain margin designed into the link is large enough to allow for splicing of broken fibers and aging effects. The flux budget is the power difference between the transmitter output power and the receiver input power for a given bit error rate.

This power is usually measured in dBm (i.e. referenced to 1 milliwatt) and is an absolute measurement. LED transmitter output power is typically between -10 and -18 dBm. Positive Intrinsic Negative (PIN) receivers with pre-amplifiers have a power input typically between -24 and -37 dBm. Using the flux budget, the link designer can determine the total losses the system links can have and still work properly.

The flux budget is divided into components. The components are the real losses in the system and the gain margin. The real losses consist of all the system losses such as cable attenuation, coupling and splicing losses. The gain margin is a reserve for future losses, such as aging and future splices. System losses and the gain margin are usually measured in dB and are a relative measurement.

The receiver dynamic range is the range of input power that can be successfully detected by the receiver (also referred to as the maximum and minimum optical input power). The variables that

can influence the flux budget include changing the transmitter power output, the receiver sensitivity, the imposed signal wavelength and system losses. Allow 3 dB for aging and 3 dB for each cable repair for a total margin of not less than 6 dB. Different wavelengths exhibit different cable attenuation; thus for links that use WDM or DWDM, the flux budget should be determined using the cable attenuation and connector losses for the wavelength with greater loss (which is usually the shorter wavelength).

****

Provide FO links with a minimum gain margin of 6 dB. The flux budget is the difference between the transmitter output power and the receiver input power required for signal discrimination when both are expressed in dBm. Ensure the flux budget is equal to the sum of losses (such as insertion losses, connector and splice losses, and transmission losses) plus the gain margin. When a repeater or other signal regenerating device is inserted to extend the length of an FO circuit, both the circuit between the transmitter and the repeater-receiver, and the circuit between the repeater-transmitter and the receiver are considered independent FO links for gain margin calculations.

2.3.3 Receiver Dynamic Range

Ensure the dynamic range of receivers is large enough to accommodate both the worst-case, minimum receiver flux density, and the maximum possible receiver flux density, with a range of at least 15 dB. Where required, use optical attenuators to force the FO link power to fall within the receiver dynamic range.

2.4 ACCESSORIES

2.4.1 FO Connectors

****

NOTE: Available FO connector types include, but are not limited to, FC, SC, Duplex SE (568SC), ST, Duplex ST, LC, Duplex LC, ESCON, FDDI, and MT-RJ. Equipment manufacturers may offer both a manufacturer's standard termination connector type and also an optional termination connector type or types as available on a specific equipment component. Whereas some equipment may only be available with one termination connector type (as an example, one manufacturer offers a choice of either ST, SC, or FC connectors on a specific FO transceiver).

For equipment additions to existing installation, the installed base of legacy systems may suggest use of a certain type of connector be continued and to be used for new equipment. Alternatively, use of hybrid adapters or hybrid cables, allows the use of cables with different connector types on opposite cable ends to permit the cable connectors to be compatible with the equipment termination connectors. Connectors with a pull-proof feature are preferable, especially for patch cords.

Nominal and maximum connector pair losses vary by connector type, by manufacturer, and by cable type (e.g., multimode or single mode). Nominal connector pair loss of 0.3 dB, and maximum connector pair loss of 0.5 dB are common for older types of FO connectors. Small form factor types and newer connector types may offer smaller nominal and smaller maximum loss value.

****

Use field installable, self-aligning and centering FO connectors. Match FO connectors with the fiber core and cladding diameters. Provide FO cable connectors at field equipment [of the type to match the field equipment connectors] [of type [_____]] [as shown]. Provide FO connectors at terminal head end equipment [of the type to match terminal head equipment connectors] [of type [_____]] [as shown]. Connector insertion loss is nominally 0.3 dB and maximum loss less than 0.7 dB.

2.4.2 Mechanical Splices

Mechanical splices are suitable for installation in the field. External power sources are not required to complete a mechanical splice. Use self-aligning mechanical splices for optimum signal coupling. Do not use mechanical splices for exterior applications where they may be buried underground or laced to aerial messenger cables. Mechanical splices may be used for interior locations and within enclosures. Protect the spliced fibers from moisture and prevent physical damage with splice closures. Use the splice closure to provide strain relief for the cable and the fibers at the splice points.

2.4.3 Fusion Splices

Use a portable, fully automatic, and compact fusion splicer, suitable for fusion splicing all types of telecommunication grade optical fibers and individual fibers as well as cables containing multiple optical fibers. Ensure the fusion splicer is capable of operation under various environmental conditions (e.g., temperature, humidity, altitude, etc.) for all types of optical cable deployments. Start the automatic splicing process by pressing one button and can be interrupted at any time. Alternatively, make available semi-automatic (step-by-step) or manual splicing by menu selection. Conduct communication with the fusion splicer through a language unspecific keyboard with universal symbols and display the dialogue with the splicer on the device screen.

2.4.4 Conduit, Fittings And Enclosures

Ensure conduit, fittings, and enclosures are as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and as shown.

2.4.5 Fan-Out Kits

****

NOTE: Provide fan-out kits (also referred to as providing buffer tube fan-out kits, or furcating harnesses, or furcation kits, or installing furcating tubes) for terminating all loose-tube optical fibers (i.e., optical fibers with 250 micron outside diameter) and additionally incorporate

strain relief if the connectorization is not contained within a patch panel. Fan-out kits with furcating tubes are typically not used for tight-buffered (e.g., 900 micron outside diameter) optical fibers which have the connectorization contained within a patch panel. Fan-out kits with strain relief furcating tubes are appropriate for field connectorization of tight-buffered optical fibers when the termination is not contained within a patch panel.

****

For all loose-tube optical fibers, furnish and install fan-out kits using furcating tubes for connectorization. Incorporate strain relief for loose-tube optical fiber furcating tubes if the connectorization is not contained within a protective enclosure such as a patch panel. For tight-buffered optical fibers, furnish and install fan-out kits using furcating tubes and which incorporate strain relief, if the connectorization is not contained within a protective enclosure such as a patch panel. Furcating tubes required to incorporate strain relief also provide increased pullout protection. Tubes are comprised of an inner tube, surrounded by a layer of nonconductive strength members, then surrounded by an enclosing outer jacket layer. [Color code fan-out kits to match the industry fiber color scheme.] Length of furcating tube is [610] [915] mm [24] [36]-inches minimum when installation is complete. Rate fan-out kits for the ambient conditions of the location as specified in paragraph ENVIRONMENTAL REQUIREMENTS. Provide terminations for each fiber, regardless whether fiber is active or spare.

2.5 CABLE CONSTRUCTION

****

NOTE: Either tight-buffer or loose-tube cable construction can be used. The loose tube construction is more appropriate where the cable is subject to thermal expansion. This would include outdoor aerial and long distance runs over 1 Km 0.62 mile. In multistory buildings or locations where the cable is installed vertically and does not experience significant temperature variations, use tight-buffer cables.

****

2.5.1 General

Ensure the cable contains a minimum of two FO fibers for each link circuit. The number of fibers in each cable is [_____] [as shown]. Protect each fiber by a protective tube. Ensure cables have a jacketed strength member, and an exterior jacket. Ensure cable and fiber protective covering are free from holes, splits, blisters, and other imperfections. Insulation and jacketing material for interior cables cannot contain any polyvinyl chloride (PVC) compounds. Use a covering that is flame retardant, moisture resistant, non-nutrient to fungus, ultraviolet light resistant as specified, and nontoxic. Do not transmit mechanical stress present in cable to the optical fibers. Ensure strength members are non-metallic and an integral part of the cable construction. Ensure the combined strength of all the strength members is sufficient to support the stress of installation and to protect the cable in service. For exterior cables, select a minimum storage temperature range of minus

40 to plus 75 degrees C minus 104 to plus 167 degrees F. A minimum storage temperature of minus 10 to plus 75 degrees C plus 14 to plus 167 degrees F is required for interior cables. Ensure all optical fiber cables and all optical fiber raceways furnished meet the requirement of NFPA 70. Apply a flooding compound into the interior of the fiber tubes, into the interstitial spaces between the tubes, to the core covering, and between the core covering and jacket of all cable to be installed aerially, underground, and in locations susceptible to moisture. Ensure flooded cables comply with TIA/EIA-455-81 and TIA-455-82. Provide cables from the same manufacturer, of the same cable type, of the same size, and of the same optical characteristics. Ensure each fiber and protective coverings is continuous with no factory splices. Certify by the manufacturer, optic cable assemblies, including jacketing and fibers, to have a minimum life of 30 years. Ensure cables meet UL 1666. Certify FO cable to meet the following: TIA-455-13, TIA/EIA-455-25, TIA/EIA-455-41, TIA-455-177, TIA-455-78-B, TIA/EIA-455-88, TIA-455-91, TIA-455-104, and TIA/EIA-455-171.

2.5.2 Exterior Cable

2.5.2.1 Aerial Cable

Surround the optical fibers by a tube buffer, contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container, and extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement. Select cable with the following characteristics:

a. Cable outer jacket: Medium density polyethylene material containing at least 2.6 percent carbon black with only black pigment added for additional coloring.

b. Tensile strength: Withstand an installation tensile load of not less than 2700 Newtons 608 pounds and not less than 600 Newtons 135 pounds continuous tensile load.

c. Impact and Crush resistance: Withstand an impact of 3 Newton-meters 1.7 lbs/in as a minimum, and have a crush resistance of 220 Newtons per square centimeter 317 psi as a minimum.

2.5.2.2 Duct Cable

Surround the optical fibers by a tube buffer, contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container, and extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement. Select cable with the following characteristics:

a. Cable outer jacket: Medium density polyethylene material with orange pigment added for ease of identification.

b. Tensile strength: Withstand an installation tensile load of not less than 2700 Newtons 608 pounds and not less than 600 Newtons 135 pounds continuous tensile load.

c. Impact and Crush resistance: Withstand an impact of 3 Newton-meters 1.7 lbs/in as a minimum, and have a crush resistance of 220 Newtons per square centimeter 317 psi as a minimum.

2.5.2.3 Direct Burial Cable

Surround the optical fibers by a tube buffer, contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container, and extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement. Select cable with the following characteristics:

a. Cable outer jacket: Medium density polyethylene material containing at least 2.6 percent carbon black with only black pigment added for additional coloring.

b. Tensile strength: Withstand an installation tensile load of not less than 2700 Newtons 608 pounds and not less than 600 Newtons 135 pounds continuous tensile load.

c. Impact and Crush resistance: Withstand an impact of 3 Newton-meters 1.7 lbs/in as a minimum, and have a crush resistance of 220 Newtons per square centimeter 317 psi as a minimum.

Protect direct burial cable with plastic coated steel armor. Apply the plastic coated steel armor longitudinally directly over an inner jacket and have an overlap of 5 mm 0.20-inch minimum. Select armoring materials that provide corrosion protection from local environmental/soil conditions over the projected life of the cable.

2.5.3 Interior Cable

Loose buffer tube cable construction is such that the optical fibers are surrounded by a tube buffer, and contained in a channel or otherwise loosely packaged to provide clearance between the fibers and the inside of the container allowing for thermal expansions without constraining the fiber. Extrude the protective container from a material having a coefficient of friction sufficiently low to allow the fiber free movement. Use fluorocopolymer (FCP) for the cable outer jacket, which complies with NFPA 70 for optical fiber nonconductive plenum (OFNP) applications. Do not exceed the manufacturers' recommended values for tensile strength, impact resistance, and crush resistance. Insulation and jacketing cable material cannot contain any polyvinyl chloride (PVC) compounds.

For tight buffer tube cable construction, use extrusion of plastic over each cladded fiber, with an outer jacket of FCP, which complies with NFPA 70 for optical fiber nonconductive riser (OFNR) requirements for riser cables and vertical shaft installations. Cover optical fibers in near contact with an extrusion tube and an intermediate soft buffer to allow for the thermal expansions and minor pressures. Do not exceed manufacturers' recommended values for tensile strength, impact resistance, and crush resistance. Insulation and jacketing cable material cannot contain any polyvinyl chloride (PVC) compounds.

2.5.4 Pigtail Cables

Use flexible fiber pigtail cables for connections to equipment having the same physical and operational characteristics as the parent cable. Ensure the cable jacket is FCP, which complies with NFPA 70 for OFNP applications. Maximum dB loss for pigtail cable is 3.5 dB/km at 850 nanometers, and 1.0 dB/km at 1300 nanometers, and [_____] dB/Km at 1550 nanometers.

PART 3 EXECUTION

3.1 INSTALLATION

Install system components and appurtenances in accordance with the manufacturer's instructions and as shown. Provide interconnections, services, and adjustments required for a complete and operable data transmission system.

Where installation procedures, or any part thereof, are required to be in accordance with the manufacturer's recommendations of the material being installed, submit printed copies of these recommendations prior to installation. Installation of the item is not allowed to proceed until the recommendations are received and approved.

3.1.1 Interior Work

****

NOTE: DTS cable should not be used for, or routed through, Sensitive Compartmented Information Facilities (SCIFs). The designer will not show any DTS cable routed through a SCIF. The designer should check DCID 1/21 for further direction.

****

Install conduits, tubing and cable trays for interior FO cable as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and as shown. Ensure cable installation and applications meet the requirements of NFPA 70, Article 770. Properly support and secure cables not installed in conduits or wireways. If installed in plenums or other spaces used for environmental air, comply with NFPA 70 requirements for this type of installation.

3.1.2 Exterior Work, Aerial

****

NOTE: Aerial cable should be installed on existing poles where height, clearance, and structure loading allow addition of cables. Where this is not possible, show requirements for new poles on drawings. Installations will comply with IEEE C2 for Grade B construction and NFPA 70. Coordinate with facility personnel for ground clearance and establish clearances to be shown on the drawings.

Verify local electrical installation requirements to determine if new grounding conductors and electrodes are required at each messenger cable ground connection and select the first, or second, or both bracketed entries as determined to be necessary.

Common lashing machines provide 1 turn per 380 linear mm (1 turn per 15 linear inches) in a single pass, which is acceptable for locations where loading due to weather conditions is moderate. Other locations may require multiple passes with the lashing machine.

Percent values stated below for messenger rated breaking strength are based upon overload factors that apply to Grade B construction. If the aerial electrical distribution system construction is a lesser grade (e.g., Grade C, Grade N, or not graded) provide differing values in accordance with NESC and actual requirements.

****

Except as otherwise specified, install poles and associated aerial hardware for an overhead FO cable system as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION, as specified herein, and as shown.

a. Furnish and install a messenger system meeting the requirements of IEEE C2 to support aerial cables. The messenger system includes all messenger support and attachment hardware and appurtenances needed to install the messenger. Ensure messenger tension due to combined ice and wind loading on the messenger with supported cables does not exceed 60 percent of the messenger rated breaking strength. Messenger tension due to extreme wind loading on the messenger with supported cables cannot exceed 80 percent of the messenger rated breaking strength. Provide messenger support and attachment hardware with a rated strength not less than the messenger rated breaking strength. Size all messenger support and attachment hardware and appurtenances to exceed the rated breaking strength of the messenger cable. Use galvanized zinc coated steel or aluminum clad steel messenger cables.

b. Ground the messenger cables at all corners, dead ends, at the entrance to each facility, and at intervals not exceeding 305 meters 1000-feet. [Provide new grounding conductors and electrodes at each ground connection.] [Where grounding connections are made in the vicinity of existing grounding conductors and electrodes, the grounding connection may be made by a bolted or welded connection to the existing grounding conductor.]

c. For aerial FO cables, meet the horizontal, vertical and climbing space clearances prescribed in IEEE C2 and those of the installation.

d. Provide transitions from aerial cable to underground cable as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION and as shown.

e. Make aerial cable splices within 1 meter 3-feet of a pole and placed inside a watertight enclosure. Form drip loops at the cable entrance to the enclosure. Place lashing clamps within 300 mm 12-inches of the enclosure.

f. Form loops in the aerial cables at points of connection and at poles to prevent damage from thermal stress and wind loading. Protect the communications cable from chafing and physical damage with the use of spiral cut tubing and PVC tape, or plastic sleeves. The ground clearance of installed cabling is as shown.

g. Vertically run cable and when possible use gravity to assist in cable pulling. Pull cable from top of run to bottom of run. Hand pull cable, if possible. If machine assistance is required, monitor tension using dynamometers or load-cell instruments and do not exceed specified cable tension limits. After installation, relieve the vertical tension on the cable at maximum intervals of 30 meters 100-

feet using a split support grip.

h. Wind lashing wire tightly around both the communication cable and the messenger cable by machine methods. Ensure the lashing wire has a minimum of 1 turn per 380 linear mm1 turn per 15 linear inches and not less than the number of turns per unit length that is recommended by the cable manufacturer for the distance between cable support points and the combined ice and wind loading and extreme wind loading specified or normally encountered loading for the installed location. Place lashing clamps at all poles and splices.

i. Provide soft drawn copper ground conductors not smaller than No. 6 AWG, having a current capacity of at least 20 percent of that of the messenger to which it is connected. Connect the ground conductor to a copper or copper clad steel ground rod not less than 19.1 mm 3/4-inch in diameter with a length as needed to achieve the specified ground resistance. After installation is completed, the top of the ground rod is approximately 300 mm 1-foot) below finished grade. Protect the ground conductor with half-round wood, plastic, or fiber molding from the ground to a point at least 2.4 m 8-feet above the ground. Measure ground resistance in normally dry conditions, not less than 48 hours after a rainfall, and the total ground resistance is not to exceed [25] [_____] ohms.

3.1.3 Exterior Work Underground

****

NOTE: For UMCS ESS or IDS projects, provide transition details in the drawings based on the details shown in UMCS/EMCS or IDS Typical Drawings and/or Standards installation Details.

****

Except as otherwise specified, install conduits, ducts, and manholes for underground FO cable systems as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION and as shown.

a. Minimum burial depth for cable is 760 mm 30-inches, but not less than the depth of the frost line. Burial depth specified takes precedence over any requirements specified elsewhere.

b. Where direct burial cable passes under sidewalks, roads, or other paved areas, place the cable in a 25 mm 1-inch zinc-coated rigid conduit or larger as required to limit conduit fill to 80 percent or less.

c. Place buried cables below a plastic warning tape buried in the same trench or slot. Place the warning tape 300 mm 12-inches above the cable. Continuously imprint the warning tape with the words "WARNING - COMMUNICATIONS CABLE BELOW" at not more than 1.2 m 48-inch intervals. Use warning tape that is acid and alkali resistant polyethylene film, 76.2 mm 3-inches wide with a minimum thickness of 0.1 mm 0.004-inch, with a minimum strength of 12066 kPa 1750 psi lengthwise and 10342 kPa 1500 psi crosswise.

d. Transitions from underground cable to aerial cable are as shown.

e. For cables installed in ducts and conduit, use a cable lubricant compatible with the cable sheathing material on all cables pulled.

Attach pulling fixtures to the cable strength members. If indirect attachments are used, match the grip diameter and length to the cable diameter and characteristics. If an indirect attachment is used on cables having only central strength members, reduce the pulling forces to ensure that the fibers are not damaged from forces being transmitted to the strength member. During pulling, continuously monitor the cable pull line tension using dynamometers or load-cell instruments. Do not exceed the maximum tension specified by the cable manufacturer. Ensure the mechanical stress placed upon the cable during installation is such that the cable is not twisted or stretched. Use a cable feeder guide between the cable reel and the face of the duct or conduit to protect the cable and guide it into the duct or conduit as it is un-spooled from the reel. As the cable is un-spooled from the reel, inspect it for jacket defects or damage. Do not kink or crush the cable. Do not exceed the minimum bend radius of the cable during installation. Hand feed and guide cable through each manhole and apply additional lubricant at all intermediate manholes. When practicable, use the center pulling technique to lower pulling tension. That is, pull the cable from the center point of the cable run towards the end termination points. The method may require the cable to be pulled in successive pulls. If the cable is pulled out of a junction box or manhole, protect the cable from dirt and moisture by laying the cable on a ground covering.

3.1.4 Service Loops

Ensure each FO cable has service loops of not less than 3 meters 9.8-feet in length at each end. House the service loops in a service loop enclosure.

3.1.5 Metallic Sheath Grounding

****

NOTE: Direct burial cables with metallic sheath are not installed when transmission of electromagnetic interference (EMI) or radio frequency interference (RFI) through the metallic sheath is a consideration.

****

Ground the FO cable with metallic sheath that enter buildings at a point as close as practivable to the building point of entrance. Ensure FO cable with metallic sheath routed in the trench with a power cable has the metallic sheath grounded at the cable termination points.

3.1.6 Splices

****

NOTE: Maximum splice loss values per ANSI/TIA/EIA-568B are 0.3 dB for fusion splices, and 0.3 dB for mechanical splices. These maximum loss values are considered larger loss values than can be provided by many manufacturers and installers. The designer will specify lesser loss values when the design and link loss budget require lesser values.

****

3.1.6.1 General

No splices are permitted unless the length of cable being installed

exceeds the maximum standard cable length available from a manufacturer or unless FO pigtails are used to connect transmitters, receivers, or other system components for terminations to the fiber. Make splices using the method recommended by the cable manufacturer. Place splices in a splice enclosure and encapsulate with an epoxy, ultraviolet light cured splice encapsulant or otherwise protected against infiltration of moisture or contaminants. Field test FO splices at the time of splicing. Ensure fusion splices have a nominal splice loss of [0.15] [_____] dB for multimode and for single mode cable fusion splices and a maximum fusion splice loss not more than 0.3 dB loss.

3.1.6.2 Mechanical Splices

Install mechanical splices with a nominal splice loss of [0.15] [_____] dB for multimode fiber mechanical splices and [0.2] [_____] dB for single mode fiber mechanical splices with a maximum mechanical splice loss not more than [0.3] [_____] dB loss for multimode and single mode fiber mechanical splices. Install no more than 1 splice per km 0.62 mile in any of the FO cables excluding terminations. Locate field splices in cable boxes. Provide sufficient cable in each splicing location to properly rack and splice the cables, and to provide extra cable for additional splices. Protect cable ends with end caps except during actual splicing. During the splicing operations, provide means to protect the unspliced portions of the cable and its fibers from the intrusion of moisture and other foreign matter.

3.1.7 Connectors

****

NOTE: Maximum connector pair losses per ANSI/TIA/EIA-568B are provided in the first bracketed entry and are considered larger than connector pair losses that can be achieved by many manufacturers and installers. Specify lesser loss values when the design and link loss budget requires lesser values. Confirm with two manufacturers minimum, that the lesser connector pair loss value can be achieved for the connector type and fiber (i.e., multimode or single mode) type.

****

Prior to and during installation of connectors, perform appropriate cleaning to ensure that any contaminant particulates larger than 0.06 micron in size are removed. Connectors are as specified in paragraph FO CONNECTORS. Connectors or splices which leave residue on the connector ferrule or optical connector "lens", are not permitted. Ensure fibers at each end of the cable have jumpers or pigtails installed of not less than 1 meter 3 feet in length. For fibers at both ends of the cable, have connectors installed on the jumpers. Ensure the mated connector pair loss does not exceed [0.7] [_____] dB. The pull strength between the connector and the attached fiber cannot be less than 22.7 kg 50 pounds.

3.1.8 Identification and Labeling

Provide identification tags or labels for each cable. For markers, tags and labels, use indelible ink or etching which does not fade in sunlight, or in buried or underground applications. Use markers, tags, and labels that do not become brittle or deteriorate for a period of 20 years due to moisture, sunlight, soil minerals, chemicals or other environmental

elements. Label all termination blocks and panels with cable number or pair identifier for cables in accordance with TIA-606 and as specified on drawings. Identify the labeling format and provide a complete record to the Government with the final documentation. Identify each cable with type of signal being carried and termination points.

3.1.9 Enclosure Sizing and Cable

Size termination enclosures to accommodate the FO equipment to be installed. Sizing includes sufficient space for service loops to be provided and to accommodate a neat layout of equipment and the bend radii of fibers and cables terminated inside the enclosure.

3.1.10 Enclosure Penetrations

Install enclosure penetrations from the bottom. Seal penetrations with rubber silicone sealant to preclude the entry of water. Internally seal conduits rising from underground.

3.2 FIELD QUALITY CONTROL

****
NOTE: Insert the title of the appropriate system specification (such as UMCS, IDS, ESS or CCTV).
****

3.2.1 General

Provide personnel, equipment, instrumentation, and supplies necessary to perform testing.

3.2.2 Field Test

Verify the complete operation of the data transmission system in conjunction with field testing associated with systems supported by the fiber optic data transmission system as specified in Section [_____] prior to formal acceptance testing. Include a flux density test in field tests. Perform these tests on each link and repeated from the opposite end of each link.

3.2.2.1 Optical Time Domain Reflectometer Tests

Perform optical time domain reflectometer tests using the FO test procedures of TIA-455-78-B. Perform an optical time domain reflectometer test on all fibers of the FO cable on the reel prior to installation. Calibrate the optical time domain reflectometer to show anomalies of 0.2 dB as a minimum. Furnish photographs of the traces to the Government. Perform an optical time domain reflectometer test on all fibers of the FO cable after it is installed. Calibrate the optical time domain reflectometer to show anomalies of 0.2 dB as a minimum. If the optical time domain reflectometer test results show anomalies greater than 1 dB, the FO cable segment is unacceptable to the Government. Replace the unsatisfactory segments of cable with a new segment of cable. Then test the new segment of cable to demonstrate acceptability. Furnish photographs of the traces to the Government for each link.

3.2.2.2 Power Attenuation Test

Perform power attenuation test at each light wavelength of the transmitter

to be used on the circuit being tested. Measure the flux at the FO receiver end and compare to the flux injected at the transmitter end. Add a jumper at each end of the circuit under test so that end connector loss is validated. Rotational optimization of the connectors is not permitted. If the circuit loss exceeds the calculated circuit loss by more than 2 dB, the circuit is unsatisfactory. Examine the circuit to determine the problem. Notify the Government of the problem and propose procedures to eliminate the problem. Prepare and submit a report documenting the results of the test.

3.2.2.3 Gain Margin Test

Test and verify that each circuit has a gain margin which exceeds the circuit loss by at least the minimum gain margin specified in paragraph FLUX BUDGET/GAIN MARGIN.

3.2.2.4 Analog Video Signal Test

Test analog video circuits. Ensure the monitor or automated test set is stable. If the result is unsatisfactory, examine the circuit to determine the problem. Notify the Government of the problem and of the procedures proposed to eliminate the problem. Prepare and submit a report documenting the results of the test.

3.2.2.5 Digital Video Signal Test

Test digital video circuits. Ensure the monitor or automated test set is stable. If the result is unsatisfactory, examine the circuit to determine the problem. Notify the Government of the problem and of the procedures proposed to eliminate the problem. Prepare and submit a report documenting the results of the test.

3.2.2.6 Performance Verification Test and Endurance Test

****
NOTE: This requirement pertains only to UMCS, IDS, ESS and CCTV projects.
****

Test the FO data transmission system as a part of the completed [UMCS] [IDS] [ESS] [CCTV] [_____] during the Performance Verification Test and Endurance Test.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Delivery of Technical Data

****
NOTE: Insert the Section title of the appropriate additional specifications: Section 28 10 05 ELECTRONIC SECURITY SYSTEMS (ESS); Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION.

For UMCS, IDS, ESS and similar systems requiring head-end computers and software, use the paragraph DELIVERY OF TECHNICAL DATA and delete paragraph SUBMITTALS. In no case will both paragraphs be retained.

****

Delivery computer software and technical data (including technical data which relates to computer software), which are specifically identified in this specification strictly in accordance with the CONTRACT CLAUSES, SPECIAL CONTRACT REQUIREMENTS, and in accordance with the Contract Data Requirements List (CDRL), DD Form 1423, which is attached to and thereby made a part of this contract. Identify by reference all data delivered to the particular specification paragraph against which it is furnished. If the data transmission system (DTS) is being installed in conjunction with another system such as an intrusion detection system, electronic SECURITY system, closed circuit television system, or utility monitoring and control system, submit the Technical Data Packages as part of the Technical Data Package for Section [_____]; submit [_____] hard copies and [_____] electronic copies (DC-ROM or DVD-R) of the Technical Data Package(s).

3.3.1.1 Group I Technical Data Package

3.3.1.1.1 System Drawings

Include the following information:

a. Communications system block diagram.

b. FO receivers, transmitters, transceivers, multiplexers, and FO modem installation, block diagrams, and wiring and cabling diagrams.

c. FO receivers, transmitters, transceivers, multiplexers, and FO modem physical layout and schematics.

d. Details of interfaces with other systems.

e. Details of connections to power sources, including grounding.

f. Details of surge protection device installations.

g. Details of cable splicing and connector installations.

h. Details of aerial cable and messenger installation on poles, cable entrance to buildings, and termination inside enclosures.

i. Details of underground cable and duct installation, cable entrance into buildings, and terminations inside enclosures.

Show on the drawings the proposed layout and anchorage of equipment, appurtenances, and equipment relationship to other parts of the work including clearance for maintenance and operations. Show the proposed configuration on the drawings, including location, type and termination of both interior and exterior FO and showing the location, duct and inner duct arrangement, and fiber assignment. Show the ac power consumption and heat dissipation under both normal and maximum operating conditions.

3.3.1.1.2 Equipment Data

Deliver a complete data package for all material, including field and system equipment.

3.3.1.1.3 Data Transmission System Description and Analyses

Include in the data package a complete system description, and analyses and calculations used in sizing equipment required by these specifications. Descriptions and calculations show how the equipment operates as a system to meet the specified performance. The data package includes the following:

a. FO receivers, transmitters, transceivers, multiplexers, FO modem transmit and receive levels, and losses in decibels (dB) on each communication link.

b. Digital transmitter and receiver communication speed and protocol description.

c. Analog signal transmission method and bandwidth of the transmitter and receiver.

d. Data transmission system expansion capability and method of implementation.

e. FO system signal-to-noise ratio calculation for each communication link.

f. Flux-budget and gain margin calculation for each communication link.

3.3.1.1.4 System Overall Reliability Calculations

****
NOTE: Insert the section that describes the system configuration.
****

The data package includes manufacturers' reliability data and calculations required to show compliance with the specified reliability. Base the calculations on the configuration specified in Section [_____], and as shown on drawings.

3.3.1.1.5 Certifications

Include the specified manufacturers' certifications with the data package.

3.3.1.1.6 Key Control Plan

****
NOTE: The designer will specify the Section in which a key control plan is found, when this specification is used with IDS, ESS, or CCTV: Section 28 10 05 ELECTRONIC SECURITY SYSTEMS (ESS); Section 25 10 10 UTILITY MONITORING AND CONTROL SYSTEM (UMCS) FRONT END AND INTEGRATION.
****

3.3.1.2 Group II Technical Data Package

****
NOTE: If the designer has specified site condition investigation in other sections, the first bracketed sentence, with the proper section number inserted,

may be substituted in lieu of the second set of bracketed sentences.
****

[The Group II technical data package is specified in Section [_____].] [Verify that site conditions are in agreement with the design package. Submit a report to the Government documenting changes to the site, or differing conditions that affect performance of the system to be installed. For those changes or conditions which affect system installation or performance, provide specification (with the report), or written functional requirements to support the findings, and a cost estimate to correct the deficiency provided with the report. Do not correct any deficiency without written permission from the Government.]

3.3.1.3 Group III Technical Data Package

****
NOTE: Insert section number and title for the UMCS, IDS, ESS or CCTV specifications.
****

Prepare test procedures and reports for the factory test in accordance with Section [_____] and this specification. The test procedures describe the applicable tests to be performed, and other pertinent information such as specialized test equipment required, length of test, and location of the test. The procedures explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements of this specification, and the methods for simulating the necessary conditions of operation to demonstrate performance of the system. The test report describes the results of testing to include the date, time, location and system component designations of material and equipment tested. Record testing action whether successful or not. Describe reasons for termination of testing. Include testing work sheets, printouts, strip charts, oscilloscope or optical time domain reflectometer (OTDR) printouts/photographs, raw and analyzed data, and testing conclusions in the report. Deliver the factory test procedures to the Government for approval. After receiving written approval of the test procedures, schedule the factory test. Provide written notice of the test to the Government at least 2 weeks prior to the scheduled start. Deliver the final test reports in booklet form within 15 days after completion of the test.

3.3.1.4 Group IV Technical Data Package

3.3.1.4.1 Performance Verification and Endurance Testing Data

****
NOTE: Insert section number and title for the UMCS, IDS, ESS or CCTV specification.
****

Prepare procedures and reports for the performance verification test and endurance test. Prepare test procedures in accordance with Section [_____] and this specification. Perform testing on an installed system as approved by the Government. Where required and approved by the Government, simulate conditions of operation to demonstrate the performance of the system. The test plan describes the applicable tests to be performed, other pertinent information such as specialized test equipment required, length of performance verification test and endurance

test, and location of the performance verification test and endurance test. The procedures explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements of this specification, and the methods for simulating the necessary conditions of operation to demonstrate performance of the system. The test report describes the results of testing to include the date, time, location and system component designations of material and equipment tested. Record testing action whether successful or not. Record reasons for termination of testing for any reason in the report. Include testing work sheets, printouts, strip charts, oscilloscope or OTDR printouts/photographs, raw data, analyzed data and testing conclusions in the report. Deliver the performance verification test and endurance test procedures to the Government for review and approval. After receipt of written approval of test procedures, schedule the performance verification and endurance tests. Provide written notice of the performance verification test and the endurance test to the Government at least 2 weeks prior to the scheduled start of the test. Deliver the final performance test and endurance test report 30 days after completion of testing.

3.3.1.4.2 Operation and Maintenance Data

Deliver a draft copy of the operation and maintenance data, in manual format, as specified for the Group V technical data package, to the Government prior to beginning the performance verification test for use during site testing.

3.3.1.4.3 Training Data

Deliver lesson plans and training manuals, including the type of training provided, with a list of reference material for approval by the Government prior to starting any training.

3.3.1.5 Group V Technical Data Package

****

NOTE: Specify the correct number of manuals on DD Form 1423. Adjust the quantities below to fill special local requirements. Coordinate O&M manual requirements with those of the performing district.

Generally, FO systems do not include controls or functions under the control of system operators. Therefore, an operator's manual is not needed. Include an operator's manual if such controls are provided.

****

The Group V package consists of the operation and maintenance data, in manual format. Deliver final copies of the manuals [bound in hardback, loose-leaf binders,][and][electroic format] to the Government within 30 days after completing the endurance test. Update the draft copy used during site testing with any changes required prior to final delivery of the manuals. Identify each manual's contents on the cover. Include with the manuals, the names, addresses, and telephone numbers of each subcontractor installing the equipment and systems, and of the nearest service representative for each item of equipment and each system. Ensure the manuals have a table of contents and tab sheets. Place tab sheets at the beginning of each chapter or section and at the beginning of each appendix. The final copies delivered after completion of the endurance

test include all modifications made during installation, checkout, and acceptance. Ensure the delivered manuals include:

a. Functional Design Manual: [two] [_____] copies [_____] hard copies [1] [_____] CD-ROM(s).

b. Hardware Manual: [two] [_____] copies [_____] hard copies [1] [_____] CD-ROM(s).

c. Maintenance Manuals: [two] [_____] copies. [_____] hard copies [1] [_____] CD-ROM(s).

d. Operator's Manual: [six] [_____] copies [_____] hard copies [1] [_____] CD-ROM(s).

3.3.1.5.1 Functional Design Manual

The functional design manual identifies the operational requirements for the data transmission system and explain the theory of operation, design philosophy, and specific functions. Include a description of hardware functions, interfaces, and requirements for all system operating modes.

3.3.1.5.2 Hardware Manual

Furnish a manual describing all equipment and devices specified and under PART 2 PRODUCTS. Include the following information:

a. General description and specifications.

b. Installation and checkout procedures.

c. Equipment electrical schematics and layout drawings.

d. Data transmission systems schematics.

e. Alignment and calibration procedures.

f. Manufacturer's repair parts list indicating sources of supply.

g. Interface definition.

3.3.1.5.3 Maintenance Manual

Include the maintenance descriptions for all equipment including inspection, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components.

3.3.1.5.4 Operator's Manual

Ensure the operator's manual fully explains procedures and instructions for operation of the system. This includes an operator's manual for any FO systems in which system operators control any function of the system.

3.3.1.6 Group VI Technical Data Package

The Group VI Technical Data Package consists of the as-built drawings revised to include system revisions and modifications. Deliver copies of the updated as-built drawings to the Government following approval of the PVT and endurance test.

3.3.2 Training

Conduct a training course for designated personnel in the maintenance of the FO system. Orient the training to the specific system being installed under this specification. Furnish all training materials and supplies.

3.3.2.1 System Maintenance Training Course

Provide [six] [_____] copies of operating instructions outlining the step-by-step procedures required for system operation including description of each subsystem in its operating mode. Instructions includes the manufacturer's name, service manual, parts list, and a brief description of equipment, components, and their basic operating features. Provide [six] [_____] copies of the maintenance instructions listing regular maintenance procedures, possible system failures, a troubleshooting guide for repairs, and simplified diagrams for the system as installed. A video describing operating and maintenance instructions may be included.

Provide a system maintenance course taught at the project site after completion of the endurance test for a period of 1 training day. A maximum of five personnel designated by the Government will attend the course. A training day consists of 8 hours of classroom or lab instruction, including two 15 minute breaks and excluding lunchtime during the daytime shift in effect at the facility. Training includes:

a. Physical layout of the system and each piece of hardware.

b. Troubleshooting and diagnostics procedures.

c. Repair instructions.

d. Preventative maintenance procedures and schedules.

e. Calibration procedures.

-- End of Section --