
USACE / NAVFAC / AFCEA UFGS-16792A (April 2004)

Preparing Activity: USACE Superseding
UFGS-16792A (July 2003)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 22 December 2004

Revised throughout - changes not indicated by CHG tags

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SECTION 16792A

WIRE LINE DATA TRANSMISSION SYSTEM

04/04

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SECTION 16792A

WIRE LINE DATA TRANSMISSION SYSTEM 04/04

NOTE: This guide specification covers the requirements for underground, aerial, direct burial, and interior wire line data transmission systems for communication between a local device and a central processor, and covers the requirements for a half or full duplex wire line data transmission system (DTS).

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

PART 1 GENERAL

NOTE: This section will be used in conjunction with Section 16415 ELECTRICAL WORK, INTERIOR; Section 16370 ELECTRICAL DISTRIBUTION SYSTEM, AERIAL; Section 16375 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND; Section 16751 CLOSED CIRCUIT TELEVISION SYSTEMS; Section 13720 ELECTRONIC SECURITY SYSTEM; Section 13451 POWER MONITORING SYSTEM; Section 13702 BASIC INTRUSION DETECTION SYSTEMS (IDS); Section 13703 COMMERCIAL INTRUSION DETECTION SYSTEM (IDS); Section 13721 SMALL INTRUSION DETECTION SYSTEM; Section 13801 UTILITY MONITORING AND CONTROL SYSTEM

(UMCS); and any other guide specification sections
required by the design.

1.1 REFERENCES

NOTE: Issue (date) of references included in
project specifications need not be more current than
provided by the latest guide specification. Use of
SpecsIntact automated reference checking is
recommended for projects based on older guide
specifications.

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

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41 (1991; R 1995) Recommended Practice for
Surge Voltages in Low-Voltage AC Power
Circuits

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

ICEA S-84-608 (2002) Telecommunications Cable, Filled
Polyolefin Insulated Copper Conductor

INTERNATIONAL TELECOMMUNICATION UNION (ITU)

ITU H.222.0 AMD 1 (2002) Information Technology Genetic
Coding of Moving Pictures and Associated
Audio Information

ITU V.44 (2000) Pre-published Data Compression
Procedures

ITU V.92 (2000) Enhancements to Recommendation V.90
Series: V, with Amendments 1 and 2

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2003) Enclosures for Electrical Equipment
(1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2005) National Electrical Code

U.S. DEPARTMENT OF AGRICULTURE (USDA)

RUS Bull 345-67 (1998) REA Specification for Filled
Telephone Cables, PE-39

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

47 CFR 15 Radio Frequency Devices

1.2 SYSTEM DESCRIPTION

1.2.1 General

NOTE: Designer must show on drawings the DTS selected for each link and the systems to be interconnected. NEC (e.g., Sections 300.11(A) and 800.5) does not permit communication circuits to be supported by suspended ceiling panels or suspended ceiling support grids. Thus, give consideration for proper support of cables and raceways.

A half or full duplex wire line data transmission system (DTS) for communication between a local device and a central processor shall be provided. The local device is used to process locally generated information and communicates that information to the central processor. The central processor is a computer-based system that takes the information received from the local processor and processes that information. The DTS shall consist of MODEMS (headend and remote) or line drivers, or both, connected to the local device and the central processor. The MODEMS are connected by transmission lines and terminal devices such as connectors and terminal strips. Communication links surge protection and powerline surge protection shall be provided at both ends of the transmission line. All computing devices, as defined in 47 CFR 15, shall be certified to comply with the requirements for Class B computing devices and labeled as set forth in 47 CFR 15.

1.2.2 Environmental Requirements

NOTE: Select equipment and cable temperature ratings within ambient temperature conditions at the project location. State additional requirements when ambient conditions are more extreme than manufacturers' equipment ratings (e.g. conformal coatings for 100% relative humidity or condensing atmospheres, enclosure heaters or coolers, etc.). The designer will show hazardous (classified) environmental area(s), type of hazard(s) and hazard classification (Class I, II, or III or combination; Division 1 or 2; Groups A, B, C, D, E, F, or G or combinations; and operating temperatures). Whenever possible, avoid placement of equipment and cables within the hazardous location to reduce installation costs, and to simplify maintenance.

1.2.2.1 Indoor and Outdoor Environments

Equipment and cable to be used indoors shall be rated for continuous operation under ambient environmental conditions of 0 to 50 degrees C 35 to 122 degrees F dry bulb and 10 to 95 percent relative humidity, noncondensing. Equipment and cable to be used outdoors shall be rated for

continuous operation under ambient environmental conditions of minus 40 to plus 70 degrees C minus 40 to plus 158 degrees F and humidity of up to 100 percent condensing or as normally encountered for the installed location. All equipment shall be rated for continuous operation under the ambient vibration conditions encountered for the installed location. Components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust or ignitable fibers or flyings, shall be rated and installed in accordance with Chapter 5 of NFPA 70 and as shown.

1.2.2.2 Hazardous Environments

Components and wiring located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust or ignitable fibers or flyings, shall be rated for the Classes, Divisions, Groups and suitable for the operating temperatures and shall be installed in accordance with Chapter 5 of NFPA 70 and as shown.

1.2.3 Electrical Requirements

**NOTE: The designer will show characteristics of
each voltage source on the drawings.**

The equipment shall operate from a voltage source as shown, plus or minus 10 percent.

1.2.4 Power Line Surge Protection

**NOTE: The designer will determine if any additional
inputs or outputs require surge protection and show
the requirement for them on the drawings, or in a
schedule.**

All equipment connected to AC circuits shall be protected from power line surges. Equipment shall withstand surge test waveforms described in IEEE C62.41. Surge protection devices shall be selected based on voltages and current ratings of components to be protected. Fuses shall not be used for surge protection.

1.2.5 Communications Circuit Surge Protection

All communications equipment shall be protected against surges induced on any communications circuit. All cables and conductors which serve as communications circuit between the local processor and the central processor shall have surge protection devices installed at each end. Protection shall be provided at the equipment and additional triple electrode gas surge protectors rated for the application on each wireline circuit shall be installed within 1 m 3 feet of the building cable entrance. Surge protection devices shall be selected based on voltages and current ratings of components to be protected. Fuses shall not be used for surge protection. The inputs and outputs shall be tested in both normal mode and common mode using the following two waveforms:

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

b. A waveform with an 8 microsecond rise time, a 20 microsecond waveform, a peak voltage of 1000 volts and a peak current of 500 amperes.

1.3 DELIVERY OF TECHNICAL DATA

NOTE: The wireline DTS will be used with either the electronic security systems (ESS), small intrusion detection system (IDS), closed circuit television systems (CCTV) the utility monitoring control system (UMCS), the power monitoring system, or the supervisory control and data acquisition (SCADA) system. The designer will select the system and supply the correct section title where appropriate:
Section 13702N BASIC INTRUSION DETECTION SYSTEMS (IDS), Section 13703N COMMERCIAL INTRUSION DETECTION SYSTEMS (IDS), Section 13720A ELECTRONIC SECURITY SYSTEM, Section 13721A SMALL INTRUSION DETECTION SYSTEM, or Section 16751A CLOSED CIRCUIT TELEVISION SYSTEMS.

All items of technical data which are specifically identified in this specification will be delivered strictly in accordance with the CONTRACT CLAUSES, SPECIAL CONTRACT REQUIREMENTS, Section 01330 SUBMITTAL PROCEDURES and the Contract Data Requirements List, DD Form 1423, which is attached to and made a part of this contract. Technical data submitted shall be coordinated with the requirements of Section [____]. All data delivered shall be identified by reference to the particular specification paragraph against which it is furnished [____] hard copies and [____] electronic copies (CD-ROM or DVD-R) of the Technical Data Package(s) shall be submitted.

1.3.1 Group I Technical Data Package

1.3.1.1 System Drawings

The data package shall include the following:

- a. Data Transmission system block diagram.
- b. MODEMS or line drivers or both, installation, block diagrams, and wiring diagrams.
- c. MODEMS or line drivers or both, physical layout and schematics.
- d. Details of connections to power sources, including grounding.
- e. Details of interconnection with served system components.
- f. Details of surge protection device installation.
- g. Details of cable splicing and connector installation.
- h. Details of underground, aerial, and messenger cable installation on poles, cable entrance to building.

1.3.1.2 Manufacturers' Data

The data package shall include manufacturers' data for all materials including field and system equipment provided under this specification.

1.3.1.3 DTS Description and Analyses

The data package shall include complete system descriptions, analyses, and calculations used in selecting equipment required by these specifications. Descriptions and calculations shall show how the equipment will operate as a system to meet the performance of this specification. The data package shall include the following:

- a. MODEM or line driver receive and transmit levels, signal-to-noise ratio calculations and assumed losses in decibels (dB) on each communication circuit. Contractor shall use manufacturer's minimum and maximum signal-to-noise ratio (db) of the actual equipment being furnished for the DTS.
- b. Communication speed and protocol description.
- c. Data transmission system expansion capability and method of implementation.

1.3.1.4 Certifications

All specified manufacturer's certifications shall be included with the data package.

1.3.2 Group II Technical Data Package

The Contractor shall verify that site conditions are in agreement with the design package. The Contractor shall submit a report to the Government documenting changes to the site, or conditions that affect performance of the system to be installed. For those changes or conditions which affect system installation or performance, provide (with the report) specification sheets, or written functional requirements to support the findings, and a cost estimate to correct the situation. The Contractor shall not perform any corrections without written permission from the Government.

1.3.3 Group III Technical Data Package

NOTE: Insert section number and title for the specification.

The Contractor shall prepare a test plan and test procedures in accordance with Section [_____] for the factory test. The test plan shall describe the applicable tests to be performed, and other pertinent information such as specialized test equipment required, length of factory test, and location of the factory test/predelivery test. The procedures shall 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 Contractor shall deliver the test plan for the factory test/predelivery test to the Government. After receipt by the Contractor of written approval of the test plan, the Contractor shall deliver the factory test/predelivery test procedures to the Government for

approval. After receipt by the Contractor of written approval of the factory test/predelivery test procedures, the Contractor may schedule the factory test/predelivery test.

1.3.4 Group IV Technical Data Package

1.3.4.1 Performance Verification Testing and Endurance Testing Data

**NOTE: Insert section number and title for the
appropriate specifications.**

The Contractor shall prepare a test plan and test procedures in accordance with Section [_____] for the performance verification test and endurance test. The test plan shall describe the applicable tests to be performed, and other pertinent information such as specialized test equipment required, and length of performance verification test. The test procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements of this specification. The Contractor shall deliver test plans for the performance verification test and endurance test to the Government. After receipt by the Contractor of written approval of the test plans, the Contractor shall deliver the performance verification test and endurance test procedures for approval. Written approval by the Government of the performance verification test procedures shall be one of the prerequisites for commencing the performance verification test as specified.

1.3.4.2 Operation and Maintenance Data

A draft copy of the operation and maintenance data, shall be delivered to the Government prior to beginning the performance verification test for use during site testing.

1.3.4.3 Training Data

Lesson plans and training data in manual format for the training phases, including type of training to be provided, with a list of reference material, shall be delivered for approval.

1.3.5 Group V Technical Data Package

1.3.5.1 Manuals

**NOTE: Unless the installation has a specific
requirement, specify two copies of all manuals;
except for the Operator's Manual, which should be
specified to be six copies.**

Final copies of the manuals bound in hardback, loose-leaf binders, shall be delivered to the Government within 30 days after completing the endurance test. The draft copy used during site testing shall be updated with any changes required prior to final delivery of the manuals. Each manual's contents shall be identified on the cover. The manuals shall include the names, addresses, and telephone numbers of each subcontractor installing equipment and systems, and of the nearest service representative for each item of equipment and each system. The manuals shall have a table of

contents and tab sheets. Tab sheets shall be placed 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 shall include all modifications made during installation, checkout, and acceptance. Manuals delivered shall include:

- a. Functional Design Manual: [2] [_____] copies [1] [_____] CD-ROM or DVR-R.
- b. Hardware Manual: [2] [_____] copies [1] [_____] CD-ROM or DVR-R.
- c. Maintenance Manual: [2] [_____] copies [1] [_____] CD-ROM or DVR-R.
- d. Operator's Manual: [6] [_____] copies [1] [_____] CD-ROM or DVR-R.

1.3.5.2 Functional Design Manual

The functional design manual shall identify the operational requirements for the data transmission system and explain the theory of operation, design philosophy, and specific functions. A description of hardware functions, interfaces, and requirements shall be included for all system operating modes.

1.3.5.3 Hardware Manual

A manual describing all equipment furnished, including:

- a. General description and specifications
- b. Installation and checkout procedures.
- c. Equipment electrical schematics and layout drawings.
- d. Data transmission system schematics.
- f. Manufacturer's repair parts list indicating sources of supply.
- g. Interface definition.

1.3.5.4 Operator's Manual

The operator's manual shall fully explain all procedures and instructions for operation of the system.

1.3.5.5 Maintenance Manual

The maintenance manual shall include descriptions of maintenance for all equipment including inspection, provide preventive maintenance, fault diagnosis, and repair or replacement of defective components. Software description, use of all diagnostic tools, loading software on the system and to the memory shall be included.

1.3.6 Group VI Technical Data Package

The Group VI Technical Data Package shall consist of the as-built drawings revised to include system revisions and modifications. Copies of the updated as-built drawings shall be delivered to the Government following approval of the PVT and endurance test.

PART 2 PRODUCTS

2.1 COMMUNICATIONS EQUIPMENT

Communications equipment for circuits between sensors and field processors, and between the field processors and central processor, shall be capable of transmitting data within the error rate specified over the distances shown.

For wireline equipment, the maximum permissible error rate shall be 1 in 100,000.

2.1.1 Modems

[MODEMS shall conform to ITU H.222.0 AMD 1 for a data rate of at least 9600 bits per second (bps)] [MODEMS shall provide and operate at 48,000 bps, both upstream and downstream, full duplex on circuits using asynchronous communications. MODEM shall have error detection auto answer/autodial, and call-in-progress detection. The MODEM shall meet the requirements of ITU V.92 and ITU V.44 for data compression standards, and shall be suitable for operating on unconditioned voice grade telephone lines in conformance with 47 CFR 68.]

2.1.2 Line Drivers

Line drivers shall transmit data at a minimum of 9600 bps over the distances as shown, and be compatible with the selected or existing wireline modems and telecommunications equipment that is operational at the installation.

2.2 WIRELINE CABLE

NOTE: The National Electrical Code has changed the classification of data cable from "Appliance Wiring Material" to "Building Wire."

The designer shall closely coordinate the drawings with the specifications to make sure that the number of pair and gauge size of conductors required by the design is available through the RUS program. If not available, delete references to RUS and specify a cable type (e.g., Type TC) that is suitable for installation in damp or wet locations.

Wireline cable shall be insulated solid copper type conforming to the following specifications. A minimum of No. 22 AWG shall be used for all applications. All interior cables' insulation and jacketing material shall not contain any poly vinyl chloride (PVC) compounds.

2.2.1 Cable Construction

All cable components shall be able to withstand the environment the cable is installed in for a minimum of 20 years.

2.2.2 Underground Cable

Underground cable as specified in ICEA S-84-608 covers mechanical and electrical requirements for filled, polyolefin insulated, copper conductor telecommunications cable. It provides alternative choices for type of

insulation, type of filling compound, core lay-ups, color code, sheath design (shielding materials, single or double jackets, and jacket thickness), and screened or non-screened core.

2.2.3 Aerial Cable

Aerial cable as specified in ICEA S-84-608 covers mechanical and electrical requirements for filled, polyolefin insulated, copper conductor telecommunications cable. It provides alternative choices for type of insulation, type of filling compound, core lay-ups, color code, sheath design (shielding materials, single or double jackets, and jacket thickness), and screened or non-screened core.

2.2.4 Direct Burial Cable

Direct burial cable as specified in RUS Bull 345-67 covers mechanical and electrical requirements for filled, polyolefin insulated, copper conductor. It provides alternative choices for type of insulation, type of armor jacket, filling compound, core lay-ups, color code, sheath design (shielding materials, single or double jackets, and jacket thickness), and screened or non-screened core.

2.2.5 Interior Cable

Interior cable, as specified in NFPA 70 covers mechanical and electrical requirements for filled, polyolefin insulated copper conductor communications cable. It provides alternative choices for type of insulation, type of jacket, filling compound, core lay-ups, color code, sheath design (shielding materials, single or double jackets, and jacket thickness), and screened or non-screened core. All interior cables' insulation and jacketing material shall not contain any poly vinyl chloride (PVC) compounds.

2.3 RACEWAY SYSTEMS

Raceway systems as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM and Section 16375A ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND and as shown shall be furnished and installed.

2.4 ENCLOSURES

NOTE: The designer will show the specific type of enclosure required on the drawings.

Enclosures shall conform to the requirements of NEMA 250 for the types specified. Finish color shall be the manufacturer's standard, unless otherwise indicated. Damaged surfaces shall be repaired and refinished using original type finish. The Contractor shall provide metallic enclosures to house the wireline DTS equipment. The enclosures shall be as specified or shown.

2.4.1 Interior

Enclosures to house wireline DTS equipment in an interior environment shall meet the requirements of NEMA 250, Type 12.

2.4.2 Exterior

Enclosures to house wireline DTS equipment in an outdoor environment shall meet the requirements of NEMA 250, Type 4.

2.4.3 Corrosion Resistant

Enclosures to house wireline DTS equipment in a corrosive environment shall meet the requirements of NEMA 250, Type 4X.

2.4.4 Hazardous Environment

Enclosures in a hazardous environment shall meet the requirements as specified in paragraph ENVIRONMENTAL REQUIREMENTS.

2.5 MESSENGER CABLE

A messenger cable system to support all aerial cable shall be furnished and installed. The messenger system shall include all guys, hardware and appurtenances needed to install the messenger cable. The messenger system shall be capable of supporting the weight of the DTS cable with the required messenger cable tensioning without exceeding 30 percent of its rated breaking strength under 16 degrees C 60 degrees F conditions of no ice and no wind. The messenger shall be sized so that ice and wind loading normally encountered at the site does not cause the messenger to exceed 50 percent of its rated breaking strength. All appurtenances, guys, and hardware shall be sized to exceed the required strength of the messenger cable. Messenger cables shall be galvanized zinc coated steel or aluminum clad steel.

2.6 TAMPER PROVISIONS

**NOTE: Use this paragraph when using this section
with Small Intrusion Detection Systems.**

Enclosures, cabinets, housings, boxes, raceways, conduits, and fittings of every description having hinged doors or removable covers, and which contain any part of the DTS circuit, connection, splices, or power supplies, shall be provided with cover operated, corrosion-resistant tamper switches, arranged to initiate an alarm signal when the door or cover is moved. Tamper switches shall be mechanically mounted to maximize the defeat time when enclosure covers are opened or removed. The enclosure and the tamper switch shall function together to disallow direct line of sight to any internal components and tampering with the switch or the circuits before the switch activates. Tamper switches shall be 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; be connected to circuits which are under electrical supervision at all times, irrespective of the protection mode in which the circuit is operating; shall be spring loaded and held in the closed position by the door cover; and shall be wired so that they break the circuit when the door or cover is disturbed. Tamper switches on the doors which must be opened to make routine maintenance adjustments to the system and to service the power supplies shall be push/pull-set, automatic reset type.

2.6.1 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 shall be protected by tack welding or brazing the covers in place. Zinc labels shall be affixed to such boxes indicating they contain no connections. These labels shall not indicate that the box is part of the security system.

2.6.2 Conduit-Enclosure Connections

All conduit-enclosure connections shall be protected by tack welding or brazing the conduit to the enclosure. Tack welding or brazing shall be done in addition to standard conduit-enclosure connection methods as described in NFPA 70.

2.6.3 Locks and Key-Lock 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.**

2.6.3.1 Locks

All locks required to be installed on system enclosures for maintenance purposes shall be UL listed, [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]. Keys shall be stamped "U.S. GOVT. DO NOT DUP." The locks shall be so arranged that the key can only be withdrawn when in the locked position. All maintenance locks shall be keyed alike and only two keys shall be furnished for all of these locks.

2.6.3.2 Key-Lock-Operated Switches

All key-lock-operated switches required to be installed on system components shall be UL listed, [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]. Keys shall be stamped "U.S. GOVT. DO NOT DUP." Key-lock-operated switches shall be two position, with the key removable in either position. All key-lock-operated switches shall be keyed differently and only two keys shall be furnished for each key-lock-operated-switch.

PART 3 EXECUTION

3.1 INSTALLATION

System components and appurtenances shall be installed in accordance with the manufacturer's instructions and as shown. All necessary interconnections, services, and adjustments required for a complete and operable data transmission system shall be provided. Loading coils shall not be installed on cables provided for use with line drivers.

3.1.1 Enclosure Penetrations

Enclosure penetrations shall be from the bottom unless the system design specifically requires penetrations from other directions. Penetrations of interior enclosures involving transitions of conduit from interior to exterior, and all penetrations on exterior enclosures shall be sealed with rubber silicone sealant to preclude entry of water. The conduit riser shall terminate in a hot-dipped galvanized metal cable terminator. The terminator shall be filled with an approved sealant as recommended by the cable manufacturer, and in such a manner that the cable is not damaged.

3.1.2 Interior Electrical Work

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

Except as otherwise specified, interior electrical work shall be installed as specified in Section 16402 INTERIOR DISTRIBUTION SYSTEM and as shown. In locations where corrosion and soil conditions are a concern, Contractor shall seek approval from Government before using steel or rigid galvanized conduit.

3.1.3 Exterior Electrical Work

3.1.3.1 Underground

Except as otherwise specified, underground electrical and communications work shall be installed as specified in Section 16375A ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND and as shown.

a. Minimum burial depth for cable shall be 762 mm 30 inches, but not less than the depth of the frost line.

b. Where direct burial cable will pass under sidewalks, roads, or other paved areas, the cable shall be placed in minimum 25 mm 1 inch diameter zinc coated steel, rigid galvanized, or schedule 40 conduit or concrete encased PVC. Conduit may be installed by jacking or trenching, as approved.

c. All buried cable shall be placed below a minimum 76.2 mm 3 inch wide plastic warning tape buried in the same trench or slot. The tape shall be 300 mm 12 inches above the cable. The warning tape shall be continuously imprinted with the words "WARNING - COMMUNICATION CABLE BELOW" at not more than 1.2 m 48 inch intervals. The plastic tape shall be acid and alkali resistant polyethylene film, 7.62 mm 3 inches wide with a minimum thickness of 102 micrometers 0.004 inch. Tape shall have a minimum strength of 12.1 MPa 1750 psi lengthwise and 10.3 MPa 1500 psi crosswise.

d. Transitions from underground cable to aerial cable shall be as specified in paragraph CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS in Section 16370A ELECTRICAL DISTRIBUTION SYSTEM, AERIAL

e. Splices shall be installed in cable boxes. A cable length of at least 1 m 3 ft shall be provided in each splicing location for future cable relocation, splicing, and re-racking. All splice enclosures (manholes, handholes, above-ground pedestals, etc.) shall have a length, width, and depth of at least twice (2X) the initial size requirement to accommodate future system work (i.e., splices). All cable ends shall be protected at all times with end caps except during actual splicing. During the splicing operations, means shall be provided to protect the unspliced portions of the cable from the intrusion of moisture and other foreign matter.

f. For cable installed in duct and conduit, a cable feeder guide shall be used between the cable reel and the face of the duct and conduit to protect the cable and guide it into the duct and conduit as it is played off the reel. As the cable is played off the reel, it shall be carefully inspected for jacket defects. Precautions shall be taken during installation to prevent the cable from being "kinked" or "crushed." A pulling eye shall be attached to the cable and used to pull the cable through the duct and conduit system. Cable shall be hand fed and guided through each manhole. As the cable is played off the reel into the cable feeder guide, it shall be sufficiently lubricated with a type of lubricant recommended by the cable manufacturer. Where the cable is pulled through a manhole, additional lubricant shall be applied at all intermediate manholes. Dynamometers or load-cell instruments shall be used to ensure that the pulling line tension does not exceed the installation tension value specified by the cable manufacturer. The mechanical stress placed upon a cable during installation shall be such that the cable is not twisted or stretched.

3.1.3.2 Aerial Cables

NOTE: Aerial cable should be installed on existing poles where height, clearance requirements, and structure loading allow addition of cables. Where this is not possible, requirements for new poles must be shown on drawings. Installations will comply with ANSI C2 and NFPA 70.

Common lashing machines provide 1 turn per 380 linear mm (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.

Except as otherwise specified or shown, aerial communications work shall be installed as specified in Section 16370A ELECTRICAL DISTRIBUTION SYSTEM, AERIAL.

a. Messenger cable System

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

Furnish and install a messenger cable system to support aerial cables. Messengers shall be attached to poles with approved clamps with not less than 15.9 mm 5/8 inch through bolts. Messenger cable tensioning shall not exceed 30 percent of its rated breaking strength under 16 degrees C 60 degrees F conditions of no ice and no wind. The messenger cable shall be stressed prior to lashing the cables to a tension higher than the final tension. This will prestretch the cable and ensure that there are minimum variations from the calculated values when the messenger is dead-ended under its final tension and sag. Messengers shall be grounded and guyed at all corners, dead-ends, entrances to each facility, and grounded at intervals not exceeding 305 m 1000 feet. [New grounding conductors and electrodes shall be provided 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.] Ground conductors shall be soft drawn copper, having a current capacity of at least 20 percent of that of the messenger to which it is connected. Ground conductors shall not be smaller than No. 6 AWG. The ground conductor shall be connected to a copper or copper-clad steel ground rod not less than 19.1 mm 3/4 inch in diameter, and length shall be as needed to achieve the specified ground resistance. After installation is completed, the top of the ground rod shall be approximately 300 mm 1 foot below finished grade. The ground conductor shall be protected by half-round wood, plastic, or fiber molding from the ground to a point at least 2.4 m 8 feet above the ground. Ground resistance shall be measured in normally dry conditions, not less than 48 hours after a rainfall, and the total ground resistance shall not exceed [25] [_____] ohms.

b. Transitions from Aerial Cable to Underground: Transitions from aerial cable to underground cable shall be as specified (and consistent with those specified) in CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS in Section 16370A ELECTRICAL DISTRIBUTION SYSTEM, AERIAL.

c. Aerial Cable Splices: All splices in aerial cable shall be within 1 m 3 feet of a pole and placed inside a watertight enclosure. Drip loops shall be formed at the cable entrance to the enclosure. Lashing clamps shall be placed within 300 mm 12 inches of the enclosure.

d. Lashing Wire: Lashing wire shall be wound tightly around both the communication cable and the messenger cable by machine methods. The lashing wire shall have a minimum of 1 turn per 380 linear mm 15 linear inches and not less than the number of turns per linear mm linear foot 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 for the installed location. Lashing clamps shall be placed at all poles and splices.

e. Stress Loops: Loops shall be formed in the aerial DTS cable at all points of connection and at all poles to prevent damage from thermal stress and wind loading. The DTS cable shall be protected from chafing and physical damage with the use of spiral cut tubing and PVC tape, or plastic sleeves. The ground clearance of installed cabling shall be as shown.

f. Enclosure Penetrations: All enclosure penetrations shall be from the bottom and shall be sealed with rubber silicone sealant to preclude the entry of water.

g. Identification and Labeling: The Contractor shall supply identification tags or labels for each cable. The labeling format shall be identified and a complete record shall be provided to the Government with the final documentation. Each cable shall be identified by type of signal being carried and termination points. All labels shall be non-fading when exposed to moisture, sunlight, soil minerals, chemicals, and other environmental elements.

h. Design Parameters

NOTE: The designer will include the data listing,
the loading conditions, including radial thickness
of ice, horizontal wind pressure, and temperature,
for both combined ice and wind loading and extreme
wind loading encountered at the project site.

The following conditions to be encountered at this installation are as follows:

- aa. Combined Ice and wind loading:
 - (1) radial thickness of ice [_____] mm inch
 - (2) horizontal wind pressure [_____] Pa psf
 - (3) constant to be added to the resultant [_____] N/m lb/ft
- bb. Extreme wind loading:
 - (1) velocity pressure exposure coefficient, wire [_____]
 - (2) basic wind speed [_____] m/s mi/h
 - (3) gust response factor, wire [_____]
 - (4) importance factor [1.0] [_____]
 - (5) shape factor [1.0] [_____]

3.2 TESTING

The Contractor shall provide all personnel, equipment, instrumentation, and supplies necessary to perform all testing.

3.2.1 Wire Line Test

The Contractor shall test each wire line pair. The Contractor shall prepare reports containing test results and shall certify in the reports conformance to the following requirements.

3.2.1.1 Attenuation

Measurements shall be made with test tone of 1004 Hz at 0 dBm. Attenuation distortion not to exceed minus 3 dB to plus 12 dB from 300 to 3,000 Hz, and minus 2 dB to plus 8 dB from 500 to 2,500 Hz referenced to the attenuation of the 1004 Hz test tone. Attenuation at 1004 Hz of less than 40 dB.

3.2.1.2 Envelope Delay

Envelope delay distortion shall be no greater than 1,750 microseconds over a range of 800 to 2,600 Hz.

3.2.1.3 Insulation Resistance

Insulation resistance wire to wire of wireline pair of at least 16,093 megohm-km 10,000 megohm-miles measured at 22 degrees C 72 degrees F.

3.2.1.4 Loop Resistance

Loop resistance of less than 1,500 ohms.

3.2.2 Contractor's Field Test

**NOTE: Designer must insert the title of the
appropriate specification.**

The Contractor shall verify complete operation of the DTS during Contractor's Field Testing as specified in Section [____]. Field test shall include a bit error rate test. The Contractor shall perform the test by sending a minimum of 100,000 bits of data on each communication link and measuring errors. The bit error rate shall be not greater than 1 out of 100,000 for each link. The Contractor shall prepare a report containing results of the field test.

3.2.3 Verification Test and Endurance

The wire line data transmission system shall be tested during the Performance Verification Test and Endurance Test as specified in Section [____].

-- End of Section --