
USACE / NAVFAC / AFCESA / NASA UFGS-27 05 13.00 10 (April 2006)

Preparing Activity: USACE Superseding
UFGS-27 05 13.00 10 (April 2004)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2013

SECTION TABLE OF CONTENTS

DIVISION 27 - COMMUNICATIONS

SECTION 27 05 13.00 10

TWO-WAY RADIO DATA ETHERNET TRANSMISSION SYSTEM

04/06

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 SYSTEM DESCRIPTION
 - 1.2.1 General
 - 1.2.2 Electrical Requirements
 - 1.2.3 Power Line Surge Protection
 - 1.2.4 Communications Links Surge Protection
 - 1.2.5 Communications Links Overvoltage Protection
- 1.3 DELIVERY OF TECHNICAL DATA AND COMPUTER SOFTWARE
 - 1.3.1 Group I Technical Data Package
 - 1.3.1.1 System Drawings
 - 1.3.1.2 Equipment Data
 - 1.3.1.3 Transmission System Descriptions and Analyses
 - 1.3.1.4 RF Area Coverage Report
 - 1.3.1.5 Manufacturer's Certifications
 - 1.3.2 Group II Technical Data Package
 - 1.3.3 Group III Technical Data Package
 - 1.3.4 Group IV Technical Data Package
 - 1.3.4.1 Performance Verification and Endurance Testing Data
 - 1.3.4.2 Operation and Maintenance Data
 - 1.3.4.3 Training Data
 - 1.3.5 Group V Technical Data Package
 - 1.3.5.1 Hardware Manual
 - 1.3.5.2 Operator's Manual
 - 1.3.5.3 Maintenance Manual
- 1.4 ENVIRONMENTAL REQUIREMENTS

PART 2 PRODUCTS

- 2.1 NAMEPLATES
- 2.2 RADIO FREQUENCY COMMUNICATION EQUIPMENT (RFCE)
 - 2.2.1 General
 - 2.2.2 Government Furnished
 - 2.2.3 Contractor Furnished
- 2.3 WIRELESS ETHERNET BRIDGE

- 2.3.1 Ethernet Bridge Requirements
- 2.3.2 Stand-by Ethernet Bridge
- 2.3.3 Hot Stand-by Protection Switch
- 2.3.4 Operating Conditions
- 2.3.5 Security
- 2.3.6 Software
- 2.4 ANTENNA SYSTEM
- 2.5 GROUND RODS
- 2.6 COMMUNICATION WIRING LINKS
- 2.7 CONDUIT
- 2.8 ENCLOSURES
- 2.9 WALL PENETRATIONS

PART 3 EXECUTION

- 3.1 INSTALLATION
 - 3.1.1 Wireless Ethernet Bridge
 - 3.1.2 Antenna
 - 3.1.3 Interior Work
 - 3.1.4 Exterior Work
 - 3.1.4.1 Underground
 - 3.1.4.2 Aerial
- 3.2 ENCLOSURE PENETRATIONS
- 3.3 IMPULSE SUPPRESSION SURGE ARRESTER GROUNDING
- 3.4 TESTING
 - 3.4.1 General
 - 3.4.2 Government Furnished RFCE Test
 - 3.4.3 Test Plan
 - 3.4.4 Contractor's Field Test
 - 3.4.5 Test Oversight
 - 3.4.6 Test Reporting
 - 3.4.7 Verification Test and Endurance Test

-- End of Section Table of Contents --

USACE / NAVFAC / AFCEA / NASA UFGS-27 05 13.00 10 (April 2006)

Preparing Activity: USACE Superseding
UFGS-27 05 13.00 10 (April 2004)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2013

SECTION 27 05 13.00 10

TWO-WAY RADIO DATA ETHERNET TRANSMISSION SYSTEM 04/06

NOTE: This guide specification covers the requirements for two-way radio data ethernet 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 items(s) or insert appropriate information.

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

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

PART 1 GENERAL

NOTE: This section will be used in conjunction with Section 27 15 19.00 10 WIRE LINE DATA TRANSMISSION SYSTEM; Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM; Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION; Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND; Section 28 20 01.00 10 ELECTRONIC SECURITY SYSTEM; Section 26 09 13 POWER MONITORING SYSTEM; Section 25 10 10 LONWORKS UTILITY MONITORING AND CONTROL SYSTEM (UMCS); and any other guide specification sections required by the design.

1.1 REFERENCES

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

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

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

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 142 (2007) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book

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 (2008) Enclosures for Electrical Equipment (1000 Volts Maximum)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 780 (2011) Standard for the Installation of Lightning Protection Systems

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 location of radio frequency (RF) equipment to be controlled. Designer must also show any Government furnished equipment (GFE). A standby bridge and hot standby protection switch may be required for critical areas.

Provide a two-way radio system for wireless data transmission from building to building (point-to-point) for the utility, monitoring and control system (UMCS) used to extend the Ethernet consisting of wireless Ethernet bridges, [hot standby protection switch], communication links, antenna systems, communication links surge and overvoltage protection, and powerline surge protection. Computing devices, as defined in 47 CFR 15, shall be certified to comply with the requirements for Class A computing devices and labeled as set forth in 47 CFR 15. The system shall be [compatible with the existing two-way radio equipment shown.] [interfaced with the UMCS as shown.]

1.2.2 Electrical Requirements

NOTE: Designer must show electrical details for power sources and UPS if required.

The equipment shall operate from an AC voltage source as shown, plus or minus 10 percent, at a frequency of 60 Hz, plus or minus 2 percent.

1.2.3 Power Line Surge Protection

Protect power line surge protection equipment connected to AC circuits from power line surges. Equipment shall meet the requirements of IEEE C62.41.1 and IEEE C62.41.2. Fuses shall not be used for surge protection.

1.2.4 Communications Links Surge Protection

Protect communications links surge protection communications equipment against surges induced on any communications link. Cables and conductors which serve as communications links shall have surge protection circuits installed at each end. Protection shall be furnished at equipment and additional triple electrode gas surge protectors rated for the application on each circuit shall be installed within 1 meter 3 feet of the building cable entrance. Surge protection shall meet the requirements of NFPA 780 guidelines and specifications and shall be able to withstand the following:

- a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.
- b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes. Fuses shall not be used for surge protection.

1.2.5 Communications Links Overvoltage Protection

Protect all communications equipment, such as repeaters and transceivers,

against overvoltage on any communications links. Cables and conductors which serve as communications links shall have overvoltage protection for voltages up to 480 Vac rms, 60 Hz installed. Instrument fuses or fusible resistors are acceptable for this application.

1.3 DELIVERY OF TECHNICAL DATA AND COMPUTER SOFTWARE

NOTE: The acquisition of technical data, data bases and computer software items will be in accordance with the Federal Acquisition Regulation (FAR) and the Department of Defense Acquisition Regulation Supplement (DFARS). Those regulations, as well as the Army and Corps of Engineers implementations thereof, should be consulted to ensure that a delivery of critical items of technical data is not inadvertently lost.

Specifically, the Rights in Technical Data and Computer Software Clause, DFARS 52.227-7013, and the Data Requirements Clause, DFARS 52.227-7031, 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 data 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 required. Include in the SPECIAL CONTRACT REQUIREMENTS with the request for proposals a payment schedule, obtainable from the UMCS-MCX at Huntsville Center. This payment schedule will define payment milestones and percentages at specified times during the contract period.

The technical data specified herein shall be delivered in accordance with Contract Clauses, Special Contract Requirements, and the Contract Data Requirements List, DD Form 1423 which is attached and made a part of this Contract. Technical data shall be coordinated with the requirements of Section [____]. Data delivered shall be identified by reference to the particular specification paragraph against which it is furnished. Data shall be organized and delivered as follows:

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. Radio System component installation and wiring diagrams.
- c. Radio System physical layout and schematics.
- d. Details of connections to power sources, including grounding.
- e. Details of surge protection device installation.
- f. Details of cable splicing and connector installations.

1.3.1.2 Equipment Data

A complete data package shall be delivered for all materials, including field and system equipment.

1.3.1.3 Transmission System Descriptions and Analyses

The Group I data package shall include complete system descriptions, analyses, and calculations used to configure required equipment. Descriptions and calculations shall show how the equipment will operate as a system to meet the specified performance requirements. Package shall include calculations and/or test results which indicate adequate signal strength to ensure reliable operation throughout areas where radio equipment is in service.

1.3.1.4 RF Area Coverage Report

The Group I data package shall include an area coverage report incorporating a topographical map with coverage indicated. The following shall be shown on the map:

- a. Location of the transmitter and antenna.
- b. Location of the most distant radio in each compass quadrant from the transmitting antenna.
- c. Radials (straight line segments indicating direction, distance and difference in elevation) from the transmitting antenna to the radio switches described in b. above.
- d. Location along each radial of any obstacle to line of sight propagation.
- e. Radiation pattern of the transmitted signal.
- f. Attenuation (dB) between the transmitting antenna and the radio switches described in b. above. The system loss shall take into account the effect of terrain variables such as distance, antenna height, obstructions, and absorption losses.
- g. System gain for each radio switch location described in b. above.

The system gain shall take into account the attenuation between the Central Station or repeater and the antennas, the gain of each antenna, and the transmission line losses.

h. Power output of the transmitter.

i. Calculated receiver input signal voltages and signal-to-noise (S/N) ratios for radio switches described in b. above.

1.3.1.5 Manufacturer's Certifications

Manufacturer's certifications shall be included with the Group I data package.

1.3.2 Group II Technical Data Package

**NOTE: Remove Group II when there is no Government
furnished equipment.**

The Group II technical data package shall include the results of the testing and calibration of the Government furnished Radio Frequency Communication Equipment (RFCE). Defective or nonrepairable equipment shall be reported. An estimate of the materials and costs required to repair or replace defective equipment shall be provided. Within 10 days after completion of testing and calibration, a certificate shall be provided that the Government furnished RFCE is in calibration and is functioning correctly.

1.3.3 Group III Technical Data Package

**NOTE: Insert section number and title for the UMCS
specification.**

The Group III technical data package shall consist of factory testing data. Prepare and submit test procedures using Section [_____] as a guide for the factory test. Explain in detail, step-by-step actions and expected results to demonstrate compliance with the specified requirements, and the methods for simulating the necessary conditions of operation to demonstrate performance of the system.

1.3.4 Group IV Technical Data Package

1.3.4.1 Performance Verification and Endurance Testing Data

**NOTE: Insert section number and title for the UMCS
specification.**

Prepare and submit test procedures using Section [_____] as a guide, excluding all surge and overvoltage tests, for the performance verification test and endurance test. Surge and overvoltage tests shall not be conducted during the performance verification test. The test procedures 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 specified requirements. Receiver input signal voltages and S/N ratios as required by the RF area coverage report shall be verified as adequate for system operation. Performance verification and endurance test procedures shall be submitted by the Contractor and approved by the Government in writing before starting tests.

1.3.4.2 Operation and Maintenance Data

A draft copy of the operation and maintenance data, in manual format, as specified for the Group V technical data package, 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

NOTE: Unless the installation has a specific requirement, specify six copies of the operator's manual and two copies of all other manuals. The number of copies must be coordinated with requirements defined in DD Form 1423.

The Group V technical data package shall consist of the system documentation. 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, bound in hardback loose-leaf binders, shall be delivered within 30 days after completion of the endurance test, and shall include all modifications made during installation, checkout, and acceptance. Manuals delivered shall include:

- a. Hardware Manual: [two] [_____] copies.
- b. Operator's Manual: [six] [_____] copies.
- c. Maintenance Manual: [two] [_____] copies.

1.3.5.1 Hardware Manual

A manual describing equipment furnished, including:

- a. General description and specifications.
- b. Installation and checkout procedures.

- c. Equipment electrical schematics and layout drawings.
- d. Alignment and calibration procedures.
- e. Manufacturer's repair parts list indicating sources of supply.
- f. Interface definition.

1.3.5.2 Operator's Manual

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

1.3.5.3 Maintenance Manual

The maintenance manual shall include descriptions of maintenance for all equipment including inspection, calibration, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components.

1.4 ENVIRONMENTAL REQUIREMENTS

Equipment to be utilized indoors shall be rated for continuous operation under ambient environmental conditions of 2 to 49 degrees C 35 to 120 degrees F dry bulb and 10 to 95 percent relative humidity, noncondensing. All other equipment shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.

PART 2 PRODUCTS

2.1 NAMEPLATES

Nameplates shall have unique identifiers engraved or stamped. Permanently attach nameplates to enclosure panel doors and back plates. For each field mounted piece of equipment attach a plastic or metal tag with equipment name and point identifier.

2.2 RADIO FREQUENCY COMMUNICATION EQUIPMENT (RFCE)

2.2.1 General

Provide all equipment needed for a complete two-way radio system for wireless data transmission from building to building (point-to-point) for the utility, monitoring and control system (UMCS) used to extend the Ethernet. The two-way radio data transmission system shall consist of wireless bridges, [hot standby protection switch], communication links, antenna systems, communication links surge and overvoltage protection, and powerline surge protection.

2.2.2 Government Furnished

NOTE: Designer must identify Government furnished
RFCE. The Government may supply the use of existing
antennas or antenna space on a tower or other
suitable geographical location.

The Government will provide RFCE as indicated. All government furnished equipment shall be tested by the Contractor to assure that the equipment is in calibration and functioning correctly. Modifications to the Contractor's system shall be compatible with the government furnished equipment.

2.2.3 Contractor Furnished

NOTE: Designer to select which components of the network are Contractor furnished or Government furnished.

A. The designer must determine if there is line of site between the point-to-point bridges. If not, then the designer must utilize antennas to create line of site.

B. The location where the point-to-point bridge or antenna is located may already contain RF equipment. If this is the case, band pass or band reject filters may be needed for simultaneous operation.

C. Designer must identify Government furnished wire lines for use as DTM with remote base station if GF wire lines are to be used and available.

D. The frequency assignment must be coordinated from the installation Director of Information Management.

All RFCE not shown as Government furnished shall be furnished and installed by the Contractor. Contractor furnished RFCE shall provide data communication operation.

2.3 WIRELESS ETHERNET BRIDGE

NOTE: The frequency assignment must be coordinated with the installation Director of Information Management, Operation range must be specified, and operating conditions must be specified. The sections below show typical operating specifications but can be adjusted to increase distance, frequency, and operating conditions.

Bridges shall be of solid state design and shall use a license-free frequency band. The bridge shall be compliant with 47 CFR 15 code. Bridges can be a single integrated unit, or it may consist of separate transmitter and receiver modules with a common power supply, amplifier and control unit. The bridge may also utilize an integrated antenna or an external antenna. The bridges shall be used to extend a connection for remote locations to allow wireless data transmission of the Ethernet.

2.3.1 Ethernet Bridge Requirements

The Ethernet bridge shall operate on a license-free frequency band of [2.4] [5] GHz. Frequency stability shall be within 0.00025 percent over the operating temperature range. The bridge shall have a minimum throughput of 8 Mbps. The bridge must have a minimum transmission power of +20 dBm. The bridge shall have a digital interface that utilizes a RJ-45 connector at a minimum of 10BaseTx transmission speed. The bridge power consumption must be less than 60 watts. There must be bi-colored or separate indicator lights for power and transmitting status. A low loss type "N" connector must be used to connect the bridge to the antenna. All interconnecting cables among station elements must be provided with bridge. The bridge shall have a minimum broadcast range of [1, 5, 10, 50] miles to allow connection between the point-to-point bridges. The bridges shall be used to extend a connection for remote locations to allow wireless data transmission of the Ethernet.

2.3.2 Stand-by Ethernet Bridge

**NOTE: A stand-by bridge and hot stand-by protection
switch may be required for critical areas.**

A stand-by Ethernet bridge shall be provided for each bridge location. The bridge shall utilize a hot stand-by protection switch. The bridge may be manually swapped from primary to backup.

2.3.3 Hot Stand-by Protection Switch

The protection switch shall simultaneously switch all radio functioning including Ethernet bridge RF, antenna, data, orderwire, diagnostics, and auxiliary data ports to the stand-by radio whenever there is a hardware failure indicated. The protection switch shall only require the use of one antenna for both bridges. The switching time shall be less than 5 seconds. There shall be status and alarm indicator lights.

2.3.4 Operating Conditions

The environmental operating conditions for the bridge shall be a minimum of 0 to 55 degrees C 32 to 131 degrees F and a maximum of 85 percent relative humidity.

2.3.5 Security

The bridges must utilize a security protocol that has a minimum of 128-bit encryption on all data being transferred from the point-to-point bridges.

2.3.6 Software

Bridges shall utilize integrated web-based network management software or a direct telnet connection for configuration and diagnostic.

2.4 ANTENNA SYSTEM

**NOTE: The designer must show the topography on the
drawings and select appropriate environmental
conditions.**

Antenna system shall be selected to be consistent with the paragraph RADIO FREQUENCY COMMUNICATION EQUIPMENT (RFCE) SYSTEM REQUIREMENTS. The antenna, when possible, shall be placed on a tall structure or similar geographical feature, such as a water tower, tall building, existing radio tower, or mountain to maintain the needed line of site to each antenna. The antenna system shall utilize vertical polarization antennas, communication links between bridges and antennas, and matching networks as needed for the proper coverage. The antenna system shall be either omni-directional or shaped-coverage as determined by the Contractor from the topography. The antenna system and cabling shall be furnished to provide adequate system gain. The antennas shall be capable of withstanding the environmental conditions of 201.2 km/hour 125 mph wind and 13 mm 1/2-inch radial ice without failure. The antenna system shall be selected by the Contractor to meet the requirements as determined from the topography. Lightning protection shall comply with NFPA 780. Grounding Conductors Antenna grounding conductors shall be minimum 32-strand, No. 17 AWG copper.

2.5 GROUND RODS

Ground rods shall be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.6 COMMUNICATION WIRING LINKS

Transmission line between the wireless bridge and the antenna shall be 50-ohm impedance rated for the transmitter output power. Minimum requirement shall be cable that exhibits an attenuation not exceeding 1.1 dB per 30.5 m 100 feet.

2.7 CONDUIT

Conduit as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND and as shown shall be furnished.

2.8 ENCLOSURES

NOTE: The designer must show where enclosures are needed on the drawings. All outdoor equipment shall utilize an enclosure. Indoor units may utilize an enclosure or be placed in existing communication racks. Coordinate the location of the indoor units with the Director of Information Management.

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. Enclosures installed indoors may be NEMA Type 1 when located in a clean dry environment, and shall be NEMA Type 12 when installed indoors in other than clean dry environment, or as shown. Enclosures installed outdoors shall be NEMA Type 4 unless otherwise shown.

2.9 WALL PENETRATIONS

Provide firestopping around all wall penetrations in accordance with

Section 07 84 00 FIRESTOPPING.

PART 3 EXECUTION

3.1 INSTALLATION

NOTE: This section must be used in conjunction with Section 25 10 10 LONWORKS UTILITY MONITORING AND CONTROL SYSTEM (UMCS); Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM; Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND; Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION; and any other guide specification sections required by the design.

System components and appurtenances shall be installed in accordance with the manufacturer's instructions and as shown. Necessary interconnections, services, and adjustments required for a complete and operable wireless radio data transmission system shall be provided and shall be fully integrated with the UMCS Ethernet. Grounding shall be in accordance with IEEE 142.

3.1.1 Wireless Ethernet Bridge

NOTE: Coordinate the location of the indoor and outdoor units with the Director of Information Management.

All system components and appurtenances shall be installed in accordance with the manufacturer's instructions. Indoor components shall be installed in communication closet utilizing existing equipment racks or in new enclosures. All outdoor components shall be installed in enclosures.

3.1.2 Antenna

Tubular radiator elements shall be plugged to prevent wind vibration fatigue. Vertical tubular elements shall have drain holes near the bottom. Outside connectors shall be snug, filled with silicone grease, and properly sealed with heat-shrink wrap suitable for ambient temperatures of minus 30 to plus 60 degrees C minus 22 to plus 140 degrees F.

3.1.3 Interior Work

All interior electrical work shall be installed as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and as shown.

3.1.4 Exterior Work

3.1.4.1 Underground

Except as otherwise specified, underground electrical work shall be installed as specified in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND and as shown.

- a. Where direct burial cable will pass under sidewalks, roads, or other

paved areas, the cable shall be placed in minimum 25 mm 1 inch rigid galvanized steel conduit. Conduit may be installed by jacking or trenching, as approved. When direct burial cable is to be placed in heavy use areas other than paved areas and where the cable may be subject to damage from heavy equipment, the cable shall be placed in minimum 25 mm 1 inch rigid PVC conduit schedule 80, buried a minimum of 1067 mm 42 inches below the surface.

b. Direct burial cable shall be placed below a minimum 75 mm 3 inch wide plastic warning tape buried in the same trench or slot. The tape shall be 305 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 meter 4 foot intervals.

c. Transitions from underground cable to aerial cable shall be as specified for CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS in Section 33 70 02.00 10 ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND.

d. Splices shall be installed in cable boxes. Sufficient cable shall be provided in each splicing location to properly rack and splice the cables, and to provide extra cable for additional splices. Proper strain relief shall be provided. 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.

e. For cable installed in ducts 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 inspected for jacket defects. Cable shall not be kinked or crushed during installation. 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 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 not be such that the cable is twisted or stretched.

3.1.4.2 Aerial

NOTE: Aerial cable should be installed on existing poles. Where this is not possible, requirements must be shown on drawings. Designer must coordinate with facility personnel for ground clearance and establish clearances to be shown on drawings.

Except as otherwise specified, aerial electrical work shall be installed as specified in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION and as shown.

a. A messenger cable system to support aerial cable shall be

furnished. The messenger system, including appurtenances, guys and hardware, shall be capable of withstanding a minimum of 20 kN 4500 pounds of tension.

b. Transitions from aerial cable to underground cable shall be as specified for CONNECTIONS BETWEEN AERIAL AND UNDERGROUND SYSTEMS in Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

c. Splices in aerial cable shall be within 1 meter 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 305 mm 12 inches of the enclosure.

d. 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 3 turns per 305 mm linear foot. Lashing clamps shall be placed at all poles and splices.

e. Loops shall be formed in the aerial cable at points of connection and at poles to prevent damage from thermal stress and wind loading. The communication 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.

3.2 ENCLOSURE PENETRATIONS

Enclosure penetrations shall be from the bottom and shall be sealed with rubber silicone sealant to preclude the entry of water.

3.3 IMPULSE SUPPRESSION SURGE ARRESTER GROUNDING

Impulse suppression surge arresters shall be grounded. Ground resistance shall be not more than 10 ohms. Connections to earth shall be made in the same manner as for secondary neutral ground rod. The aerial portions of surge arrester and secondary neutral ground conductors shall be separate from and independent of each other but both grounds shall be bonded together below grade at the ground rods, or to the ground counterpoise, as applicable and the ground rods shall be spaced a minimum of 6.1 m 20 feet apart.

3.4 TESTING

3.4.1 General

Demonstrate compliance of the two-way Radio Data transmission System with the contract documents. Furnish personnel, equipment, instrumentation, and supplies necessary to perform site testing. Ensure that test personnel are regularly employed in the testing and calibration of radio data transmission systems. Testing shall include the field tests and the performance verification tests. Field tests shall be conducted by the Contractor to determine the system is completely operational. Performance verification test shall be a demonstration to the Government to ensure proper operation of all the components and proper execution of the sequence of operation.

3.4.2 Government Furnished RFCE Test

Test the Government furnished RFCE and certify that the equipment is in calibration and functioning correctly.

3.4.3 Test Plan

Submit and obtain approval of the field test plan and performance verification test plan for each phase of testing before beginning that phase of testing. Give to the Contracting Officer written notification of planned testing at least 30 days prior to test. Notification shall be accompanied by the proposed test procedures. In no case will the Contractor be allowed to start testing without written Government approval of field test plan and performance verification test plan.

3.4.4 Contractor's Field Test

Verify the complete operation of the two-way radio data transmission system during the Contractor's Field Testing. The Contractor's Field Test shall include an error rate test. Perform the test by sending 100,000 commands and measuring the error rate. The error rate shall be not greater than 5 out of 100,000. Prepare a report containing results of the field test.

3.4.5 Test Oversight

Tests are subject to oversight and approval by the Contracting Officer.

3.4.6 Test Reporting

Before scheduling the performance verification test, furnish field test documentation and written Certified Statement of Field Test Completion to the Contracting Officer for approval. The statement, certified by the two-way radio data transmission system provider, states that the installed system has been tested and is ready for the performance verification test. Do not start the performance verification test prior to receiving written permission from the Government. During and after completion of the Field Tests, and again after the Performance Verification Tests, identify, determine causes, replace, or repair equipment that fails to meet the specification, and submit a written report to the Government. Document all tests with detailed test results. Explain in detail the nature of each failure and corrective action taken. Provide a written report containing test documentation after the Field Tests and again after the Performance Verification Tests.

3.4.7 Verification Test and Endurance Test

Test the two-way radio data transmission system as a part of the completed UMCS during the Performance Verification Test and Endurance Test as specified in Section 25 10 10 LONWORKS UTILITY MONITORING AND CONTROL SYSTEM (UMCS).

-- End of Section --