TR No. AMSEL-IE-TI-06001-7

DEPARTMENT OF THE ARMY
UNITED STATES ARMY INFORMATION
SYSTEMS ENGINEERING COMMAND
FORT HUACHUCA, ARIZONA 85613-5300

UNITED STATES ARMY INFORMATION SYSTEMS ENGINEERING COMMAND WORLDWIDE OUTSIDE PLANT DESIGN AND PERFORMANCE REQUIREMENTS

BY

STANDARDS COMMITTEE

MARCH 2006

FORT DETRICK ENGINEERING DIRECTORATE

DISCLAIMER

The use of trade names in this document does not constitute an official endorsement or approval of the use of such commercial hardware or software. Do not cite this document for advertisement.

CHANGES

Refer requests for all changes that affect this document to: USAISEC, ATTN: AMSEL-IE-DE, Fort Detrick, MD 21702-5000.

DISPOSITION INSTRUCTIONS

Destroy this document when no longer needed. Do not return it to the organization. Safeguard and destroy this document with consideration given to its classification or distribution statement requirements.

UNITED STATES ARMY INFORMATION SYSTEMS ENGINEERING COMMAND WORLDWIDE OUTSIDE PLANT DESIGN AND PERFORMANCE REQUIREMENTS

BY

STANDARDS COMMITTEE

MARCH 2006

U.S. ARMY INFORMATION SYSTEMS ENGINEERING COMMAND
FORT DETRICK ENGINEERING DIRECTORATE

Distribution C

Distribution authorized to U.S. Government agencies and their specified contractors only, for administrative or operational use, March 2006. Refer other requests for this document to Commander, U.S. Army Information Systems Engineering Command, ATTN: AMSEL-IE-DE, Fort Detrick, MD 21702-5000.

Product Certification

Signatures below indicate that this product does not develop a design or require a formal architectural review and complies with all USAISEC standards.

MICHAEL STINGER
Team Leader
Outside Plant Team

CONNIE SLYE
Division Leader
Infrastructure Division

EUGENE BAKER
Director
Fort Detrick Engineering Directorate

KEITH A. MOORE
Acting Director
Synchronization and Integration Group

ACKNOWLEDGEMENT

Thanks to the following individuals for their participation in this effort:

Mr. Clarence Byard; U.S. Army Information Systems Engineering Command (USAISEC), Fort Detrick Engineering Directorate (FDED), 1435 Porter Street, Fort Detrick, MD 21702; commercial 301-619-6429, Defense Switched Network (DSN) 343-6429

Mr. Dennis Christensen; USAISEC-FDED, 1435 Porter Street, Fort Detrick, MD 21702; commercial 301-619-6514, DSN 343-6514

Mr. Mark Hasty; USAISEC-FDED, 1435 Porter Street, Fort Detrick, MD 21702; commercial 301-619-6493, DSN 343-6493

Mr. Redick Hatfield; USAISEC-FDED, 1435 Porter Street, Fort Detrick, MD 21702; commercial 301-619-6526, DSN 343-6526

Mr. Eugene Kraeger; USAISEC-FDED, 1435 Porter Street, Fort Detrick, MD 21702; commercial 301-619-6236, DSN 343-6236

Mr. Ed Peduzzi; USAISEC-FDED, 1435 Porter Street, Fort Detrick, MD 21702; commercial 301-619-6513, DSN 343-6513

Mr. Robert Price; USAISEC-FDED, 1435 Porter Street, Fort Detrick, MD 21702; commercial 301-619-6520, DSN 343-6520

Mr. Richard Saunders; USAISEC-FDED, 1435 Porter Street, Fort Detrick, MD 21702; commercial 301-619-6537, DSN 343-6537

Mr. Fred Skroban; USAISEC-FDED, 1435 Porter Street, Fort Detrick, MD 21702; commercial 301-619-6487, DSN 343-6487

Mr. Michael Stinger; USAISEC-FDED, 1435 Porter Street, Fort Detrick, MD 21702; commercial 301-619-6517, DSN 343-6517

Mr. Vearl Sutherland; USAISEC-FDED, (Retired).

EXECUTIVE SUMMARY

This document provides specifications for designing and installing a telecommunications outside plant (OSP) infrastructure under the Installation Information Infrastructure Modernization Program. This document is a companion to the Installation Information Infrastructure Architecture Technical Guide.

This document provides a consolidated source of the U.S. Government's approved practices and materials to be used in the design and installation of the telecommunication infrastructure. This document augments and reinforces current U.S. Government policy and telecommunications industry practices. The primary focus of the document is to describe and define the items, systems, and procedures required to install a state-of-the-art, fully functional, telecommunications infrastructure that meets the current and future needs of a facility.

The telecommunications infrastructure, as referenced in this document, encompasses the systems typically installed within a fixed station (post, camp, station) environment to provide communication links to the permanent, official use structures used to support the warfighter. These systems include telecommunication pathways and spaces (conduits, maintenance holes, pole lines, etc.), transmission media (fiber optic and copper cables), cable terminations, multiplexing equipment, and environmentally controlled telecommunication spaces. This document also addresses the quality assurance aspects for the design and installation of these systems.

As the International Standard for implementation of the OSP is in draft, this document uses North American standards and practices until the International Standard is approved. Earthing and equipotential bonding (grounding) practices will follow the practices set in the USAISEC-FDED, *Grounding and Bonding Guide*, January 2004. European cable and wiring will be used in lieu of North American cable and wiring. European-unique design and performance requirements are addressed and identified using International Standards Organization dimensions. Other theaters use Imperial dimensions, unless otherwise specified by a Statement of Work. See Appendix B – European Theatre-Unique Design Considerations.

This document does not address the types of the communications information being transported through the telecommunication infrastructure; that information can be found in other publications such as the *Common User Installation Transport Network Gigabit Ethernet Data Design Guide,* March 2002.

TABLE OF CONTENTS

Page

Appendices

TABLE OF CONTENTS (CONTINUED)

Page

Tables

Figures

UNITED STATES ARMY INFORMATION SYSTEMS ENGINEERING COMMAND WORLDWIDE OUTSIDE PLANT DESIGN AND PERFORMANCE REQUIREMENTS

1.0 PURPOSE

This document provides engineering and installation standards for outside plant (OSP) infrastructure for projects in the Installation Information Infrastructure Modernization Program (I3MP). The I3MP is now the collection of programs that support the core enterprise information infrastructure at Army posts, camps, and stations worldwide. The I3MP encompasses the Defense Data Network (DDN) program; Common User Information Transport Network (CUITN); Digital Switched Systems Modernization Program (DSSMP); Installation Information Assurance Architecture (I2A2); Army Defense Information Systems Network Router Program (ADRP); fiber, cable, and OSP; and Enterprise Systems Management (ESM). The I3MP also includes the Army Knowledge Management (AKM) http://www.army.mil/ciog6/akm.html Goal 3 activities, encompassing server consolidation, Windows 2000 (W2K) Update, and Active Directory (AD).

Items included under OSP infrastructure are maintenance hole and duct, copper cable, fiber optic cable (FOC), main distribution frame (MDF), terminations, cable vaults, multiplexing equipment, environmentally controlled housings, and cross-connects. System design, integration, and quality assurance (QA) services are also part of this documentation.

This set of requirements supplements the site-specific Statement of Requirements (SOR) or Engineering Design Plan (EDP). This document contains the generic practices used in the development of the engineering and installation packages.

Although these standards cover the majority of the installation conditions, exceptions will occur. Instances requiring a waiver to the standards will be documented in the engineering package and will require U.S. Government approval.

2.0 SYSTEM DESIGN AND INTEGRATION SERVICES

2.1 References

A complete list of references used in this document is provided in Paragraph 3.2 (Table 1).

2.2 General

The contractor will provide information systems engineering, installation, and testing support in response to tasking documents that define the specific tasks. The various elements of work are described in, but not limited to, the following paragraphs. Any unique tasks not covered below will be specified in the site-specific SOR/EDP.

2.2.1 Information Systems Engineering, Installation, and Testing

The contractor will perform information systems engineering to translate the requirements and performance objectives of a selected system approach into design criteria and specifications for the implementation of individual elements and subsystems that will make up that system. More specifically, the elements within the information systems integration arena will include supporting structures (maintenance hole and duct), copper cable, FOC and systems, video, carrier systems, timing equipment, Synchronous Optical Network (SONET) equipment, power systems, digital systems, equipment cabinets/racks, and cross-connect systems. The contractor's systems integration process will incorporate system-of-systems planning and design to include the following:

a. Determining the interoperability at all interfaces within and external to the system (hardware and software), including the necessary supporting equipment and facilities, and other systems and equipment that will be present or required in the operational environment.

b. Conducting and/or supporting investigations of systems performance, systems integration, systems interoperability, and problems with fielded systems and recommending alternative solutions.

2.2.2 Site Survey

The contractor will perform site surveys. The contractor will collect, collate, analyze, and document the technical and supporting information required to complete the detailed engineering of the supporting structures and cable plant upgrade defined in the site-specific SOR/EDP.

2.2.3 Detailed Information

During the site survey, the contractor will collect the detailed information required to enable development of an engineering design to satisfy the infrastructure requirements identified in the site-specific SOR/EDP and the supporting structures and cable spreadsheets.

2.2.4 Survey Pathways

The contractor will survey all existing maintenance holes and ducts serving any affected buildings/areas to determine/verify their adequacy to support the required cable upgrades. In order to be considered sufficient, the maintenance holes and duct systems must have enough spare capacity to support the current cable upgrades, as well as to allow vacant ducts for future expansion. In general, this means that the contractor will not use the last duct available in any existing duct segment because this would not provide vacant ducts for future use. However, there are instances where placing an inner duct into a vacant 4-in duct may provide sufficient growth potential for the future. An example of this would be an entrance duct into a smaller building where the new cable could be installed in inner duct with sufficient room remaining to allow for installation of the largest copper cable required to accommodate the single line concept for current users in the building.

The U.S. Government may identify specific instances where this would be acceptable in Attachment A to the site-specific SOR/EDP. In his proposal, the contractor will specifically identify any instances where he is planning to use the last available duct in this manner. The contractor may also propose the installation of new cable into ducts that are already occupied with cable if he believes the new cable can be installed without damaging it or the existing cable(s). In his proposal, the contractor will specifically identify where he plans to use this approach. The contractor will provide the size of the duct, number, size, and type of existing cables, and the number, size, and type of new cables to be installed in this manner. If this approach is approved, the contractor will be liable for any damage to any of the cables during installation. A 100-millimeter (mm) (4-in) inside diameter entrance cable duct may be considered partially full if it contains cables of 25-mm (1-in) diameter or less that fill less than 40 percent of the cross-sectional area of the duct.

2.2.5 Building Entries

The standard method for entering buildings with new cable is underground through subsidiary or lateral conduits for underground cable, and through galvanized rigid steel conduit (RSC) stub-outs from the building for direct-buried (DB) cable.

Typical foundation types encountered include slab-on-grade, crawl space, full basement, and deep drilling on piles. Footers encountered may be continuous or non-continuous. The footer portion of the foundation will not be cut. Entrance conduits will pass below footers or through the building foundation wall. Galvanized RSC will be placed where the entrance conduits pass through foundation walls. Annular spaces between the conduits and floors and walls will be sealed to prevent water intrusion. Entrance conduits will be plugged or sealed to prevent water intrusion. Where conduits cannot be placed within 75 mm (3 in) of a wall as shown in Figure C-5 (Figure C-10 for Europe) – Pedestals and Building Entrance Details the conduits will enter a pull box within the building.

Entrance conduits will not be mounted on the exteriors of buildings, unless previously approved by the U.S. Government. The location of existing main telephone terminal rooms on floors above ground level is insufficient by itself to justify mounting entrance conduits on the exterior of buildings. Where approved by the U.S. Government, the amount of conduits mounted on the external walls of buildings will be minimized. Pull boxes will be placed where conduits penetrate external walls. The pull boxes will be sized to allow fiber optic and copper cables sized for the building, whether or not copper cables will be placed by this project. Electrical-metallic tubing (EMT) will not be used on the exteriors of buildings. Conduits mounted on the exterior of buildings will be hidden from view in a manner approved and as directed by the U.S. Government.

2.2.6 Building Entrance Ground

Refer to the USAISEC *Grounding and Bonding Guide*, January 2004.

2.2.7 New Building Ducts

If new ducts for a new cable entrance are to be installed into the building (e.g., because all of the existing ducts are in use), they will be sized and placed to permit the installation of both copper and FOC adequate to serve the building, even if only FOC will be placed by this project.

2.2.8 Site-specific Construction Requirements

The contractor will meet with the site Directorate of Public Works (DPW), or equivalent, to verify any site-specific construction requirements, as identified in the site-specific SOR/EDP. Some areas for consideration are road, sidewalk and parking area crossings, railroad crossings, stream crossings, bridge crossings, etc. The contractor will also verify the specific installation procedure as defined in the site-specific SOR/EDP (e.g., cut and resurface/push and bore), to be used prior to the start of construction.

2.2.9 Site Survey Report

The contractor will prepare a Site Survey Report (SSR) in a commercially acceptable contractor format. The contractor will deliver three copies of the SSR; one copy will be sent to the Defense Communications System (DCS) theater project manager (PM), DCS-Europe (PM DCS-E) or DCS-CONUS (PM DCS-C) or DCS-Pacific (PM DCS-P); one copy to the site Directorate of Information Management (DOIM); and one copy to the technical point of contact (TPOC) at the United States Army Information Systems Engineering Command, Fort Detrick Engineering Directorate (USAISEC-FDED). The SSR will include the following as a minimum:

- A listing of any discrepancies found within the SOR/EDP, site map/cable route, and the spreadsheets provided.
- A list of all details and agreements pertaining to equipment, equipment locations, and facilities.
- A list of any expected problem areas, along with proposed solutions.
- A detailed schedule for the engineering and implementation of the project.

Approval of the site survey report by the U.S. Government does not constitute approval of contractor-proposed changes listed in the report, which will be reviewed and approved separately.

2.2.10 Site Preparation

As part of an overall system design and installation, the contractor may be required to perform site preparation support. All proposed support will be documented in the site-specific SOR/EDP. Site preparations may include the following:

a. Mechanical requirements, such as environmental control to allow for equipment operating temperatures and humidity, heat emission of electronic equipment, and ventilation requirements, etc., to support the SOR/EDP.

b. Electrical requirements, such as power requirements, technical and non-technical power panels, lighting and receptacle requirements, and proper grounding facilities, etc., to support the SOR/EDP, including 48-volts direct current (VDC) equipment.

c. Equipment Moves – The movement of existing electronics, relay racks, electrical equipment, etc., necessary to make floor space available for the installation of new cable and equipment.

d. The installation of concrete huts or underground vaults.

2.2.11 Equipment Configuration

The contractor will determine the equipment configuration needed to translate the design approach and system requirements into a configuration that can be produced, installed, tested, integrated, and supported within the state of existing or economically achievable technology and support capability. The equipment configuration will include the following:

a. Review of any proposed equipment configuration.

b. Review of all calculations showing the fiber optic loss budget limitations.

c. Review of detailed wiring diagrams and single-line diagrams for circuits to be installed or modified by the installers.

d. Review of single-line and block diagrams of representative communications complexes.

2.2.12 System Design and Integration

The contractor will determine system configurations, equipment interfaces, bandwidth, attenuation, loading, and circuit design.

2.2.13 Design Reviews

2.2.13.1 Initial Design Review (IDR)

The contractor will prepare and conduct the IDR at the specific project site to allow U.S. Government review of the initial design. The contractor will furnish the following standard commercial deliverables to the site DOIM, Project Manager, Defense Communications and Army Switched Systems (PM DCASS), and USAISEC-FDED, as specified in the SOR/EDP. Project information to be reviewed will include project status and schedule; updated building tier list; OSP drawings with cable routes; maintenance hole locations; cut and resurface locations; building drawings with entrance locations and equipment locations; the bill of materials; and material specifications required to document the engineering design proposed to satisfy the requirements of the project specified in the SOR/EDP.

The engineering drawings will depict the routes and/or placement of all maintenance holes, hand holes, pedestals, and DB cable. Use of existing maintenance holes and ducts will be clearly depicted. They will also define all road cuts and/or bores as agreed to with the site DPW. Copies of the items will be provided in hard copy, as well as electronic format whenever possible. The contractor will develop minutes of the meeting and will provide copies to the site DOIM, PM DCASS, and USAISEC-FDED in electronic format via electronic mail.

2.2.13.2 Critical Design Review (CDR)

The contractor will prepare and conduct the CDR at the specific project site to allow U.S. Government review of the final design. The contractor will furnish the following standard commercial deliverables, reflecting all changes resulting from the IDR, to the site DOIM, PM DCASS, and USAISEC-FDED, as specified in the SOR/EDP. Project information to be reviewed will include project status and schedule, updated building tier list, engineering drawings, and the bill of materials and material specifications required to document the engineering design proposed to satisfy the requirements of the project specified in the SOR/EDP. Copies of the items will be provided in hard copy, as well as electronic format when possible. The contractor will develop minutes of the meeting and provide copies to the site DOIM, PM DCASS, and USAISEC-FDED in electronic format via electronic mail.

2.2.14 External Project Impacts

Other entities beyond the control of the DOIM and PM DCASS may identify requirements that will impact the scope of the project. These could include force protection, the Provost Marshal's Office (PMO), DPW, fire protection, etc. The designer should be aware of these requirements and coordinate with the Integrated Product Team (IPT) Leader on the impact of these on the project.

2.2.15 Pre-construction Meeting

Prior to the start of construction, the contractor and the contractor's on-site PM will coordinate and schedule a pre-construction meeting with the DOIM, facility engineer, project engineer, DPW, fire, safety, security, and other affected personnel.

2.2.16 Equipment Location Coordination

The contractor and the contractor's on-site PM will coordinate with the appropriate post engineer and project officer to confirm the exact location of all new cable, equipment, and maintenance holes and ducts prior to the start of excavation.

2.2.17 Excavation Coordination

The contractor and the contractor's on-site PM will coordinate with the post engineer and submit written requests for digging permits for all excavation, to include scheduling of all road closings, the cutting/boring of roadways, and marking the right-of-ways of conduit paths. Local post policy regarding in-ground installation of conduit and maintenance holes as stated in the site-specific SOR/EDP will have precedence and will override any stated directives contained within this document.

2.2.18 Contractor Recommendations

As the installation progresses, the contractor will make recommendations of components required to overcome unforeseen obstacles in order to meet installation requirements (i.e., verify measurements, power requirements, floor space and cable routes) and submit red-lined project drawings to the USAISEC-FDED for review. All proposed changes/solutions should be reviewed and approved by the U.S. Government prior to implementation.

2.2.19 Periodic Report

The contractor will provide monthly comprehensive status and progress reports which will include a narrative description of work accomplished during the reporting period, fiscal data for the reporting period, cumulative fiscal data, revisions to the milestone chart, and an overview of activities planned for the next quarter. The report will also address and review work accomplished during the previous time interval, work planned for the next time interval, problems encountered and the status of their resolution, problems anticipated that may impact the cost and scope, and recommendations for schedule changes.

2.2.20 Drawings

The contractor will develop and maintain drawings for the project. These drawings will be considered deliverables and will be reviewed by the U.S. Government for technical solutions, adherence to guidelines, and to ensure that they address the entire project/task.

2.2.20.1 Engineering Drawings

The contractor will develop engineering drawings for review at each design review. As a minimum, the contractor-developed drawings will show new work involving the following:

a. OSP Drawings – The contractor will annotate the OSP drawings with the proposed maintenance hole and duct routes, proposed location of DB cable excavations, cables and splices, cut and resurface locations, and building entries on the U.S. Government-provided map. The maps will be scaled site maps and/or plant-in-place drawings provided as part of the site-specific SOR/EDP. Typical drawing symbols are shown in Figure C-2 (Drawing Symbols). Complete maintenance hole and duct routes, buried cable excavation locations, and cut and resurface locations are required for both the IDR and the CDR.

b. Cable Routes – The contractor will annotate proposed cable routes, splice points, and cable counts on the Computer-Aided Design (CAD) file provided by the U.S. Government. Complete cable routes and splice points are not required for the IDR submission. A representative sample of the cable route and splice point drawings is required at the IDR for review of the contractor's format. All cable route and splice point drawings are to be submitted at the CDR.

c. Building Drawings – These will detail the equipment locations with equipment face (generic or block) elevations, which will include rack and/or wall elevations. The drawings will also show cable routes within the building, power panel locations, grounding, etc.

d. Cable vault schematics.

e. Floor plan/MDF layouts.

f. Maintenance Hole Butterfly Drawings – The contractor will develop maintenance hole butterfly drawings for all newly-installed maintenance holes and will update or create maintenance hole butterfly drawings for existing maintenance holes. These drawings will include all of the work that the contractor will perform and will depict the duct assignments, cable routing, splicing, and racking as they are to be installed in the maintenance hole. A representative sample of the butterfly drawings is required at the IDR, for review of the contractor's format. All butterfly drawings are to be submitted at the CDR.

2.2.20.2 Final Redline Drawings

Throughout the installation process, the contractor will maintain an up-to-date redline copy of all changes made to the original project design drawings. The contractor will, upon completion of the final subsystem acceptance test, furnish two sets of the redline project design drawings to show the routing of cables, placement of terminals, all splice points, maintenance hole butterflies, and all major components. The redlined project drawings will follow the same format as the drawings provided with the SOR/EDP. If electronic drawings are provided under the SOR/EDP, the contractor will use these files as the basis for the final submission. The redline project design drawings will be submitted as specified in the SOR/EDP. A copy of the drawings (electronic and hardcopy) will be provided to the USAISEC-FDED and to the site DOIM.

2.2.20.3 Drawing Format

The contractor will use AutoCAD, Release 2002 or a fully compatible package to create or update the project design drawings that will be provided as specified in the SOR/EDP.

2.2.20.4 Drawing Standards

The drawings will meet the standards and guidelines set forth in FED-STD-1037B; American National Standards Institute (ANSI) Y32.9-1972; Institute for Electrical and Electronics Engineers (IEEE)-315-1975; and IEEE-315A-1994. See Table 1 for the complete list of references.

2.2.21 Test Plan

In accordance with (IAW) the SOR/EDP, the contractor will submit for U.S. Government review a draft test plan in contractor format of all proposed cabling and equipment being installed under the project. Upon approval, the contractor will prepare a finalized test plan and forward it to the U.S. Government as specified in the SOR/EDP.

The test plan will cover, as a minimum, all of the tests cited in Section 4.0, Quality Assurance (QA). It will include the test objectives, a description of the tests to be conducted, test equipment to be used, and the criteria for acceptance. A general test plan which describes the test procedures and acceptance criteria for copper cable and FOCs is acceptable.

In addition to other standards identified herein, tests identified in the test plan will be IAW the standards and guidelines set forth in Rural Utilities Service (RUS) Bulletin 1753F-201;

RUS Telephone Engineering and Construction Manual (TE&CM) Standard PC-4; RS-455; RS-422; RS-423; ANSI/ASQC Q94-1987; ANSI Electronic Industries Association/ Telecommunications Industry Association (EIA/TIA) 492; ANSI EIA/TIA 568-B1 (Annex H), and applicable equipment manuals. See Table 1 for the complete names of these references.

2.2.22 Test Notification

The contractor will notify the U.S. Government no less than ten working days prior to conducting any final acceptance testing. Notification, which can be provided by e-mail, will consist of the following as a minimum:

- Location of testing
- Dates of testing to include start date and estimated duration
- Scope of testing – Identify all components and quantities to be tested (e.g., three 144-strand, FOCs, one 600-pair cable, fiber optic multiplexer system, etc.).

2.2.23 Test Report

Within 30 days of the completion of acceptance testing, the contractor will submit a test report for all copper and FOC and equipment installed under the project.

2.2.23.1 Format

The test report can be in contractor format and may be provided as either electronic or hard copy. The data will be presented in an effective and logical manner.

2.2.23.2 Content

a. The cover page and title page will contain the following:
   - Report date
   - Report number
   - Contract/delivery order number
   - Contractor's name and address
   - Project location
   - Date or period of testing
   - Name and address of required U.S. Government agency
   - Security classification, downgrading and declassifying information (if applicable)

b. The Table of Contents will identify the following:
   - Title and starting page of each major section, paragraph, and appendix
   - Page, identifying number, and title of each illustration (e.g., figure, table, photograph, chart, and drawing)

c. The Introduction will include the following:
   - Purpose of the test
   - Item(s) being tested

- Test requirements, including identification (ID) of the tests to be conducted and pass/fail criteria

d. The Summary will include the following:

- Brief discussion of significant test results, observations, conclusions, and recommendations that are covered in more detail elsewhere in the report
- Proposed corrective actions and schedules for repair/replacement of any failed item(s)
- Identification of any deviation, departures, or limitations encountered
- Tables, graphs, illustrations, or charts that help simplify presentation of the summary data

e. The Reference Documents section will contain a complete ID of all documents referenced in the test report, including the following (as applicable):

- Prior test reports on the same item(s)
- Test plan and procedures
- Requirement specifications and standards
- Prior certifications of compliance
- Contractor's file designation for test records
- Input parameters used

f. The Body of the test report will include the following:

- Identification of test equipment, including nomenclature, model number, serial number, manufacturer, calibration status, and accuracy data for each piece of equipment used throughout the test
- Test inspection procedures used in conducting the tests including ID of the item being tested, summarized sequence of testing steps, and test equipment setup

g. The Test Inspection Results and Analysis will include the following:

- All recorded data, such as data files from automated test equipment
- Tabulation of all pass/fail results by item
- Discussion of all discrepancies/failures, including their cause, impact, and proposed corrective action

h. The Conclusions will include the following:

- Effect of the tests in measuring item performance
- Success or failure of the item(s) to meet the required specifications
- Need for repeat, additional, or alternative testing
- Need for improved test procedures, techniques, or equipment
- Adequacy and completeness of the test requirements

i. The Recommendations will include the following (as applicable):
   - Acceptability (pass/fail) of the tested item
   - Additional testing required
   - Corrective action to be taken
   - Recommended test procedure changes

3.0 OUTSIDE PLANT

3.1 Scope

This section contains the engineering, installation, and material guidance for the installation of OSP infrastructure and electronics. An overall schematic for OSP sizing of duct and cable is provided in Figure C-1 (Figure C-7 for Europe) – OSP Infrastructure Standards.

3.2 References

Table 1 lists the references used for this document.

Table 1. References

Priority	Source	Identifier	Title	Source URL
1	Army	N/A	Site-Specific EDP	N/A
2	Army	N/A	Outside Plant Design and Performance Requirements (OSPDPR)	N/A
3	BICSI	CO-OSP, 2nd edition, 2001	CO-OSP Design Manual / CD-ROM Set	https://www.bicsi.org
4	ASTM	ASTM D2239	Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based On Controlled Inside Diameter	http://www.astm.org
4	ASTM	ASTM D 2447	Specification for Polyethylene (PE) Plastic Pipe, Schedule 40 and Schedule 80 Based On Controlled Outside Diameter	http://www.astm.org
4	ASTM	ASTM D3350	Standard Specification for Polyethylene Plastic Pipe and Fittings Materials	http://www.astm.org
4	ASTM	ASTM A139	Standard Specification for Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over)	http://www.astm.org
4	ANSI	ANSI/TIA/EIA-568-B	Commercial Building Telecommunications Cabling Standards Set	http://global.ihs.com.
4	ANSI	ANSI/TIA/EIA-569-A-1-2000	Addendum (ADD) 1 - Surface Raceways	http://global.ihs.com
4	ANSI	ANSI/TIA/EIA-569-A-98	Commercial Building Standard for Telecommunications Pathways and Spaces	http://global.ihs.com
4	ANSI	ANSI/TIA/EIA-569-A-2-2000	Addendum 2 - Furniture Pathways and Spaces	http://global.ihs.com
4	ANSI	ANSI/TIA/EIA-569-A-3-2000	Addendum 3 - Access Floors	http://global.ihs.com
4	ANSI	ANSI/TIA/EIA-569-A-4-2000	Addendum 4 - Poke-Thru Fittings	http://global.ihs.com
4	ANSI	ANSI/TIA/EIA-569-A-6	Addendum 6 – Multi-Tenant Pathways and Spaces	http://global.ihs.com
4	ANSI	ANSI/TIA/EIA-569-A-7-2001	Addendum 7 – Cable Trays and Wire Lines	http://global.ihs.com
4	ANSI	ANSI/TIA/EIA-607-A-2002	Commercial Building Grounding and Bonding Requirements for Telecommunications	http://global.ihs.com

Table 1. References (continued)

Priority	Source	Identifier	Title	Source URL
4	ANSI	ANSI/TIA/EIA-758-1-1999	Addendum 1 to TIA/EIA-758	http://global.ihs.com
4	ANSI	ANSI/TIA/EIA-758-99	Customer-Owned Outside Plant Telecommunications Cabling Standard	http://global.ihs.com
4	ANSI	NFPA-70	National Electric Code (NEC) 2002	http://global.ihs.com
4	ANSI	T1.105-2001	Synchronous Optical Network (SONET)-Basic Description including Multiplex Structure, Rates and Formats	http://webstore.ansi.org
5	ANSI	Y32.9-1972	Graphic Symbols for Electrical Wiring and Layout Diagrams used in Architectural and Building Construction (DOD adopted)	http://webstore.ansi.org
4	TIA/EIA	TIA/EIA-422-B	Electrical Characteristics of Balanced Voltage Digital Interface Circuits	http://global.ihs.com
4	TIA/EIA	TIA/EIA-423-B	Electrical Characteristics of Unbalanced Voltage Digital Interface Circuits	http://global.ihs.com
4	TIA/EIA	TIA/EIA-472	Generic Specifications for Fiber Optic Cables	http://global.ihs.com
5	IEEE	IEEE-315-1975	Graphic Symbols for Electrical and Electronic Diagrams	http://webstore.ansi.org
5	IEEE	IEEE-315-1975	Graphic Symbols for Electrical and Electronic Diagrams	http://webstore.ansi.org
5	TTC	Technical Report #2001.04	Guidelines for Pipe Ramming	http://www.latech.edu
5	Federal	FED-STD-1037C	Telecommunications: Glossary of Telecommunication Terms	http://www.its.bldrdoc.gov
5	RUS	LIST OF PROCEDURES, ITEM PL	RUS Acceptance Procedures For Splice Closures, Non-Filled, Free-Breathing And/Or Pressurized	www.usda.gov/rus/telecom/publications/bulletins.htm
5	RUS	1751F-630	Design of Aerial Plant	www.usda.gov/rus/telecom/publications/bulletins.htm

Table 1. References (continued)

Priority	Source	Identifier	Title	Source URL
5	RUS	1751F-640	Design of Buried Plant - Physical Considerations	www.usda.gov/rus/telecom/publications/bulletins.htm
5	RUS	1751F-641	Construction of Buried Plant	www.usda.gov/rus/telecom/publications/bulletins.htm
5	RUS	1751F-642	Construction Route Planning of Buried Plant	www.usda.gov/rus/telecom/publications/bulletins.htm
5	RUS	1751F-643	Underground Plant Design	www.usda.gov/rus/telecom/publications/bulletins.htm
5	RUS	1751F-644	Underground Plant Construction	www.usda.gov/rus/telecom/publications/bulletins.htm
5	RUS	1751F-802	Electrical Protection Grounding Fundamentals	www.usda.gov/rus/telecom/publications/bulletins.htm
5	RUS	1753F-201	RUS Standard for Acceptance Tests and Measurements of Telecommunications Plant	www.usda.gov/rus/telecom/publications/bulletins.htm
5	RUS	345-72	REA Specification for Filled Splice Closures, PE-74	www.usda.gov/rus/telecom/publications/bulletins.htm
5	RUS	Form 515a	Specifications and Drawings for Construction of Buried Plant (RUS Bulletin 1753F-150)	www.usda.gov/rus/telecom/publications/bulletins.htm
5	RUS	Form 515b	Specifications and Drawings for Underground Plant (RUS Bulletin 1753F-151)	www.usda.gov/rus/telecom/publications/bulletins.htm
5	RUS	Form 515d	Specifications and Drawings for Service Entrance Installations at Customer Access Locations (RUS Bulletin 1753F-153)	www.usda.gov/rus/telecom/publications/bulletins.htm
4	Telcordia	GR-111	Generic Requirements for Thermoplastic Insulated Riser Cable	http://telecom-info.telcordia.com
4	Telcordia	GR-1400	SONET Dual-Fed Unidirectional Path Switched Ring (UPSR) Equipment Generic Criteria	http://telecom-info.telcordia.com
4	Telcordia	GR-253	Synchronous Optical Network (SONET) Transport Systems: Common Generic Criteria	http://telecom-info.telcordia.com
4	Telcordia	GR-421	Generic Requirements for Metallic Telecommunications Cables	http://telecom-info.telcordia.com
4	Telcordia	MDP-326-170	Pressure Tight Splice Closures	http://telecom-info.telcordia.com
6	Lucent	621-400-011	Guying Definitions	http://www.lucentdocs.com
5	RUS	Form 515c	Specifications and Drawings for Construction of Aerial Plant (RUS Bulletin 1753F-152)	www.usda.gov/rus/telecom/publications/bulletins.htm

Table 1. References (continued)

Priority	Source	Identifier	Title	Source URL
6	Lucent	622-020-020	Conduit and Manhole Construction General	http://www.lucentdocs.com
6	Lucent	622-020-100	General Conduit and Conduit Couplings - Description	http://www.lucentdocs.com
6	Lucent	622-100-010	Conduit and Manholes Precautions	http://www.lucentdocs.com
6	Lucent	622-300-211	Main Conduit Reinforcing	http://www.lucentdocs.com
6	Lucent	622-500-011	Manholes - General	http://www.lucentdocs.com
6	Lucent	622-505-210	Concrete manholes Cast-In-Place Construction	http://www.lucentdocs.com
6	Lucent	622-506-100	Precast Concrete Manholes, 38Y Types Description	http://www.lucentdocs.com
6	Lucent	622-506-200	Manholes, Precast Concrete 38Y-Type Installation 38Y-Type Installation	http://www.lucentdocs.com
6	Lucent	622-520-100	Manholes-Equipping	http://www.lucentdocs.com
6	Lucent	622-520-100 ADD	Manholes-Equipping	http://www.lucentdocs.com
6	Lucent	626-107-006	AR-Series Riser Cables Description, Use Reel Lengths	http://www.lucentdocs.com
6	Lucent	627-610-225	Placing Metallic Riser and Building Cable	http://www.lucentdocs.com
6	Lucent	628-200-200	Underground Cable Placing, Rodding and Cleaning Ducts	http://www.lucentdocs.com
6	Lucent	628-200-206	Underground Cable, Pulling Cable Into Subsidiary Ducts	http://www.lucentdocs.com
6	Lucent	628-200-208	Underground Cable Placing	http://www.lucentdocs.com
6	Lucent	628-200-216	Fiber Optic Cable Placing in Innerduct and Direct Buried Duct	http://www.lucentdocs.com
6	Lucent	629-200-205	Guidelines for Trenching, Backfilling, and Ground restoration of Buried Plant	http://www.lucentdocs.com
6	Lucent	629-200-206	Guidelines for Placing Buried Plant	http://www.lucentdocs.com
6	Lucent	629-200-215	Buried Plant Plowing	http://www.lucentdocs.com
6	Lucent	900-200-318	Outside Plant Engineering Handbook	http://www.lucentdocs.com
6	Lucent	901-350-300	Feeder Cable--Size	http://www.lucentdocs.com
6	Lucent	915-251-300	Outside Plant Design--Distribution Cable Design	http://www.lucentdocs.com
6	Lucent	917-152-200	Distribution Cable Design--Cable Sizing and Transmission	http://www.lucentdocs.com
6	Lucent	917-356-001	Engineering and Implementation Methods System for New Buried Distribution Facilities	http://www.lucentdocs.com
6	Lucent	917-356-100	Buried Urban Distribution Systems	http://www.lucentdocs.com
6	Lucent	917-356-100 ADD	Buried Urban Distribution Systems	http://www.lucentdocs.com
6	Lucent	917-356-201	Buried Non Urban Cable Systems	http://www.lucentdocs.com
6	Lucent	918-117-090	Clearances for Aerial Plant	http://www.lucentdocs.com
6	Lucent	918-117-090 ADD	Clearances for Aerial Plant	http://www.lucentdocs.com
6	Lucent	919-000-100	Design of Communication Lines Crossing Railroads	http://www.lucentdocs.com
6	Lucent	919-120-150	Pole Lines Numbering of Poles	http://www.lucentdocs.com
6	Lucent	919-120-200	Pole Lines Classification and Loading	http://www.lucentdocs.com
6	Lucent	919-120-200 ADD	Pole Lines Classification and Loading	http://www.lucentdocs.com
6	Lucent	919-120-600	Pole Lines Design Considerations	http://www.lucentdocs.com
6	Lucent	919-240-300	Underground Conduit Manholes	http://www.lucentdocs.com
6	Lucent	919-240-400	Underground Conduit Materials Types and Fields of Use	http://www.lucentdocs.com

Table 1. References (continued)

Priority	Source	Identifier	Title	Source URL
6	Lucent	919-240-500	Underground Conduit Special Construction	http://www.lucentdocs.com
6	Lucent	919-240-520	Conduit Bridge Crossings	http://www.lucentdocs.com
6	Lucent	919-240-520 ADD	Conduit Bridge Crossings ADD	http://www.lucentdocs.com
5	IEEE	NESC 2002	National Electrical Safety Code (NESC) 2002	http://standards.ieee.org/nesc/
N/A	Army	N/A	USAISEC-FDED, Grounding and Bonding Guide	N/A
4*	ISO	BS EN 50173-1	Information Technology - Generic Cabling Systems - Part 1: General Requirements and Office Areas	http://global.ihs.com
4*	ISO	BS EN 50174-1	Information Technology – Cabling Installation - Part 1: Specification and Quality Assurance	http://global.ihs.com
4*	ISO	BS EN 50174-2	Information Technology – Cabling Installation - Part 2: Installation Planning and Practices Inside Buildings	http://global.ihs.com

*For projects in Europe only.

ASTM=American Society for Testing and Materials; BICSI=Building Industry Consulting Services, International; CD-ROM=compact disk-read only memory; DIN=Deutsches Instutut für Normung e.V.; DOD=Department of Defense; GR=Generic Requirements; ISO=International Standards Organization; N/A=not applicable; NFPA=National Fire Protection Association; TTC=Trenchless Technology Center; URL=Universal Resource Locator; VDE=Verband der Elektrotechnik Elektronik Informationstechnik

3.2.1 Priorities

In the event of conflicts between the references, the highest priority reference will govern, (i.e., a Priority 1 reference will supersede a Priority 2 reference, etc.).

3.2.2 Field Manual 11-486-5

Field Manual (FM) 11-486-5 is included for information only to help the contractor understand U.S. Army-owned outside cable plant and as-built drawings.

3.3 Environmental and Historical Considerations

Most military installations contain areas that may be affected by environmental or historical matters. Environmental hazards may include toxic waste, fuel spillage/leakage, asbestos, unexploded ordnance, etc. Wildlife preservation may be another area of concern at some sites. Compliance with historical restrictions will require special engineering considerations (type of exterior facing, mounting of terminals, placement of pedestals, etc.). These types of situations will be further defined in the site-specific SOR/EDP. The contractor, IAW the site's documented procedures for clean and/or environmentally hazardous material as specified in the site-specific SOR/EDP, will accomplish disposal of waste materials.

3.4 General Considerations

3.4.1 Digging Permits

The contractor will coordinate with the site DPW to schedule all excavation and obtain the required digging permits. Permission (approved digging permits) will be obtained from the site prior to the start of any excavation and/or construction.

3.4.1.1 Utility Location

The DOIM/DPW will be responsible for the location and marking of the utilities, unless otherwise stated in the site-specific SOR/EDP. The contractor will furnish a schedule of proposed excavation involving utility locations to the DOIM/DPW in sufficient time to allow marking. Since each DOIM/DPW has different operating requirements, the location lead-time will be stated in the site-specific SOR/EDP. An acceptable utility mark will be within 600 mm (24 in) of the edge of the utility. After the utilities have been located and marked, the contractor is responsible for maintaining the marks until they are no longer required. The intent is that the utilities will be located and marked only once and not after each rainfall.

3.4.1.2 Pot Holing

The contractor is responsible for positively determining the exact location and depth of all marked utilities suspected to be within 600 mm (24 in) of the proposed excavation or directional drilling by hand digging and/or pot holing to insure the trenching or boring/drilling equipment does not damage the utilities. When pot holing in road surfaces prior to boring operations, the initial hole will not be larger than 300 mm x 300 mm (12 in x 12 in). However, the hole may be increased in size as needed to determine the exact size and depth of the utility being located.

3.4.1.3 Slot Trenching

With the approval of the U.S. Government, the contractor may use vacuum excavation equipment to dig slot trenches. Slot trenches may be used for the installation of conduit or cable through congested areas having poorly marked utilities that cannot be avoided by adjusting cable routes.

3.4.2 Road Crossings

The cable route will be planned to cross the road only as necessary to serve subscribers without the use of aerial inserts. Such crossings will be constructed by cutting or sawing perpendicularly across the road, by trenching perpendicularly across the road, by directional boring under the road, or by pipe pushing under the road. Pavements will not be cut where the traffic detection wires of traffic light control systems are embedded.

3.4.2.1 Cuts and Resurfaces

Cuts should typically extend at least six in beyond either side of the trench to provide a stable base for the surface material, unless otherwise directed by the SOR/EDP. Roads, streets, parking lots, etc., should only be closed for as long as is required to complete the work to place the duct (including tamping the backfill) and to allow the slurry, concrete, and/or asphalt to properly set IAW manufacturer's specifications.

Once the concrete or slurry has set, the surface will be restored to original conditions within 72 hours, unless otherwise approved by the government. Certain streets or roadways may have cutting restrictions or special requirements that require traffic be resumed as soon as possible. Contractors will be prepared to comply with these restriction and requirements. Steel plates may be used as an option to open the street to traffic while the material is curing.

3.4.2.2 Dowels

Construction joints resulting from restoration in concrete pavement in excess of 180-mm (7-in) thick or subjected to heavy vehicle traffic will be doweled. Dowels may be required in thickness of less than 180 mm (7 in), as specified by the DPW or equivalent.

3.4.2.3 Right-of-Ways and Easements

The U.S. Government will verify and document that for any crossing requiring a right-of-way permit or easement, such permit will be available to the contractor. The contractor will be responsible for obtaining the appropriate permits and approvals in a timely manner to ensure compliance with established completion dates.

3.4.3 Materials

The following are materials that may be encountered.

3.4.3.1 Rock

Rock will consist of boulders measuring 0.382-cubic meter (cm^3) (1/2-cubic yard [yd^3]) or more, or other material such as rock in ledges, bedded deposits, unstratified masses, and conglomerate deposits, or below-ground concrete masonry structures, that cannot be moved without systematic drilling and blasting or the use of a rock saw. Pavements will not be considered as rock. Excavate rock to a minimum of 100 mm (4 in) below the trench depths required to place the duct bank or cable. Backfill the rock excavation and all excess trench excavation with a cushion of sand at least 100 mm (4 in) prior to placing the duct or cable. Refer to Appendix A for additional excavation details.

3.4.3.2 Unstable Soil

When wet or otherwise unstable soil that is incapable of properly supporting the conduit or maintenance hole is encountered in the trench bottom, the contractor will, at no additional cost to the U.S. Government, remove such soil to the depth required, establish a sound base, and backfill the trench to trench bottom grade with coarse sand or fine gravel. The site U.S. Government representative will determine if the soil is unstable. Refer to Appendix A for additional details on trenching. Applicable safety procedures (Occupational Safety and Health Administration (OSHA), host nation, and local) will be followed for shoring or sloping.

3.4.3.3 Select Backfill

Select backfill is defined in Appendix A Paragraph 2.1.7. The DB duct system will be buried in layers of select backfill whenever the DB duct system is not concrete-encased. The backfill will be placed IAW commercial standards and Appendix A, whichever is more stringent. The contractor will obtain the signature of the on-site U.S. Government quality control (QC)/QA representative, signifying the acceptability of the duct placement and spacing, prior to placing any backfill over the duct.

3.4.3.4 Flowable Fill or Slurry

The portion of the trench above concrete-encased duct systems under roads and parking lots will be backfilled with flowable fill, also known as slurry. The flowable fill will have a compression strength rated between 345 and 689 kilopascal (kPa) (50 to 100 pounds per square inch [PSI]). Flowable fill will not be used as a substitute for concrete encasement.

3.4.4 Backfilling

IAW Appendix A, all excavated areas around the new maintenance holes, ducts, or cables will be backfilled with approved excavated materials consisting of earth, loam, sandy clay, sand, gravel, and soft shale free from large clumps.

3.4.4.1 Placement

Backfill materials will be deposited and tamped in 150-mm (6-in) layers until the conduit has a cover of not less than 300 mm (1 ft). The remainder of the backfill materials will be placed into the excavation and then tamped in 300-mm (1-ft) layers. The earth will be graded to a reasonable uniformity, mounded, and left in a uniform and neat condition.

3.4.4.2 Unsatisfactory Materials

Blasted rock, large boulders, broken concrete or pavement will not be used as backfill materials.

3.4.4.3 Other Materials

A slurry or flowable fill type backfill can be used in lieu of a tamped backfill. The slurry or flowable fill will have a compression strength rated between 345 and 689 kPa (50 to 100 PSI) once it has set up. Flowable fill will not be used as a substitute for concrete encasement.

3.4.5 Restoration

Restoration to the same condition, as found prior to construction will be completed within 72 hours for all areas where no additional intrusion is required. Roads, streets, parking lots, etc., should only be closed for as long as is required to complete the work and allow the slurry, concrete, and/or asphalt to properly set IAW manufacturer's specifications. Certain streets or roadways may have cutting restrictions or special requirements that require traffic be resumed as soon as possible. Contractors will be prepared to comply with these restrictions and requirements.

3.4.5.1 Improved Areas

Roadways, walks, paved areas, and other surfaces disturbed by the contractor will be resurfaced with same type of material and to the same thickness as the original surface. Roadways will have a minimum thickness of 90 mm (3.5 in) of resurfaced pavement.

3.4.5.2 Grass

All grass surfaces will be leveled and reseeded, unless otherwise directed, such as the placement of sod in the site-specific SOR/EDP. For grassy areas where the contractor will have to bring heavy equipment back onto the construction site, the areas will be rough graded and covered with protective matting to prevent erosion. For durations longer than two weeks between construction and final disturbance, the contractor will rough seed the area to provide cover until final grading and seeding are accomplished.

3.4.5.2 Dowels

Construction joints resulting from restoration in concrete pavement in excess of 180-mm (7-in) thick or subjected to heavy vehicle traffic will be doweled. Dowels may be required to have a thickness of less than 180 mm (7 in) as specified by the DPW or equivalent.

3.4.5.3 Cleanup

Areas impacted by the contractor's construction (roads, sidewalks, parking lots, etc.) will be maintained free from waste, debris, washout, etc. The contractor will clean any mud tracks built up on roads, parking lots, etc., or washouts within 24 hours or as specified by the U.S. Government.

3.4.6 Detection of Buried Cables and Underground Conduits

3.4.6.1 Warning Tape

All warning tape will be polyethylene plastic tape, a minimum width of 150 mm (6 in.), IAW APWA Uniform Color Code, and imprinted with the words "WARNING - TELECOMMUNICATION CABLE BELOW" at not more than 1.2-m (48-in) intervals. Minimum thickness of the tape will be 0.10 mm (0.004 in). Tape will have a minimum strength of 12.0 MPa (1750 PSI) lengthwise and 10.3 MPa (1500 PSI). Tape will be manufactured with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 920-mm (3-ft) deep. The materials in the warning tape will be chemically inert and will not degrade when exposed to acids, alkalis, and other destructive substances found in soil.

3.4.6.2 Detection Wire for Non-Metallic Piping

Detection wire will be insulated, single strand, solid copper with a minimum of 12 American Wire Gauge (AWG) coated with a minimum 30-mm PE jacket designed specifically for buried use.

3.4.6.3 Detectable Warning Tape Installation

Detectable warning tape will be installed 305 mm (12 in) to 405 mm (18 in) above all new non-metallic conduit formations and DB cable installations, and will not exceed the manufacturer's recommended depth below grade. Tape will be placed at a depth of no less than 310 mm (12 in) below surface grade. Buried cables include cables placed in open trenches and cables placed by plowing.

3.4.6.4 Permanent Tracer Wire

Permanent tracer wire will be installed in all new duct banks (the conduits may contain a toneable cable today, but it might be removed in the near future). One tracer wire will be installed per duct bank. The tracer wire will be placed centrically as possible in the top conduit formation. When dielectric cable is installed in existing conduit formations that do not contain toneable cables, a tracer wire will be installed along with the dielectric cable. Splices in the tracer wire will be connected by means of a compression-type connector to ensure continuity. Wire nuts will not be used. After installation, tracer wire should be tested to verify continuity of the tracer wire system and a report indicating continuity should be submitted to the permitting authority as part of the as-built construction records.

3.5 Outside Plant Cable Placement Options

Underground pathways and spaces may be dedicated for cable placement (e.g., DB cable, buried duct/conduit, maintenance holes, hand holes, and shared space, such as a utility tunnel providing other services).

3.5.1 Underground

An underground maintenance hole and duct system, as required due to utility congestion, high traffic, or high building density, will be used as the preferred method for placement of outside cable plant in new construction and rehabilitation within the site cantonment areas, unless otherwise specified in the site-specific SOR/EDP. The existing maintenance hole and duct system will be leveraged to the maximum extent possible by the repair and reuse of damaged existing conduit runs and maintenance holes (where economically feasible) and by reinforcing existing full conduit runs with new conduits. Existing maintenance holes may be overbuilt to an adequate size with U.S. Government approval.

3.5.2 Direct Buried

The DB cable plant system is the preferred method for placement in less congested areas.

3.5.3 Aerial

Aerial cable plant systems will not be used except as specified in the site-specific SOR/EDP. Exceptions may include range cables or other long runs through undeveloped areas, in cases where underground systems cannot be installed, or in conformance to local mandates. Aerial pathways and spaces may consist of poles, messenger wire, anchoring guy wires, splice closures, and terminals.

3.6 Underground (Maintenance Holes, Cable Vaults, and Ducts)

Supporting documentation for the design and construction of maintenance holes, cable vaults, and duct systems is found in ANSI/TIA/EIA-758, *BICSI Customer Owned Outside Plant Telecommunications Cabling Standard;* RUS Bulletin 1751F-643/RUS Form 515C; RUS Bulletin 1751F-644; and RUS Bulletin 1753F-151. See Table 1 for the complete names of these references.

3.6.1 Maintenance Holes

Maintenance holes are used to facilitate placing and splicing of cables. Telecommunications maintenance holes will not be shared with electrical installations other than those needed for the telecommunications equipment.

Maintenance holes are reinforced concrete units provided with a removable lid that permits internal access via ladder or rungs to the housed components. They accommodate cables, splice closures, racking systems, and low voltage electronic equipment. Maintenance holes will be equipped with corrosion-resistant pulling irons and cable racks that are grounded, and a sump for drainage.

Maintenance holes will be installed on a leveled, crushed, washed, gravel base of sufficient depth, a minimum thickness of 150 mm (6 in) under the entire maintenance hole, to allow for drainage and stability. Where maintenance holes are installed in roadways, the structure and lid (cover) will support heavy vehicular traffic. See Figure C-4 (Figure C-9 for Europe) – Typical Maintenance Hole for additional details.

3.6.1.1 Types

The preferred maintenance hole is a pre-cast reinforced concrete, splayed or non-splayed, multi-directional type with cast-in single or multiple plastic terminators to accept the conduits. Thin concrete knockout sections may be provided for terminating multiple-bore conduits. The preferred maintenance hole interior size is 3.7 meters (m) (length) x 1.8 m (width) x 2 m (height) [12 ft x 6 ft x 7 ft]. Other sizes may be used only with U.S. Government approval. Splayed maintenance holes should be provided near Dial Central Offices (DCO) and remote switching units (RSU), where future duct expansion is expected. Maintenance holes will have a load rating of H-20 for heavy vehicular traffic.

3.6.1.2 Basic Layout

Maintenance holes in main or lateral duct runs will not be placed more than 180m (600 ft) apart without prior approval of the U.S. Government. Measurements between maintenance holes are from lid to lid (center-to-center), unless otherwise indicated. Measurements from maintenance holes to buildings, to pedestals, to riser poles, etc., are from the maintenance hole lid to the outside wall, bottom of pole, etc., (center-to-point). New maintenance holes will be placed to support the locations of junction points, offsets, load points, and curvature in the duct line.

3.6.1.3 Accessories

Each new maintenance hole will be equipped with a lid, sump, pulling-in irons, ground rod, bonding ribbon, cable racks, and hooks. Accessories will be designed for use in a telecommunications maintenance hole. Cable hooks will be placed IAW RUS Bulletin 1751F-643, RUS Bulletin 1753F-151, and the *AT&T Outside Plant Engineering Handbook*, August 1994, Practices 632-305-215 and 919-240-300, to support the weight of the cable and splice case.

a. Maintenance Hole Lids – A maintenance hole will include a point of egress for maintenance personnel. The maintenance hole lid will be circular and not less than 765 mm (30 in) in diameter and will not violate the H-20 load rating of the maintenance hole. Additional lids or oversized lids may be provided for maintenance holes with special uses (i.e., oversized maintenance holes, maintenance holes containing carrier or loading equipment, or maintenance holes located outside a DCO). The lid will fit in a steel ring or frame and be equipped with a concrete collar to be at grade level, as required. The frame and collar will be attached to the maintenance hole IAW the manufacturer's instructions, but as a minimum, the lid will form a watertight seal and will resist lateral movement if accidentally bumped.

b. Locking Covers – The first maintenance hole outside a DCO or wire node, maintenance holes at critical junctions, or maintenance holes equipped with carrier equipment will have lockable covers. Additional maintenance holes may be identified as requiring lockable covers in the Statement of Work (SOW)/EDP. The preferred lockable lid cover is one that utilizes a lever and clamp mechanism placed into a receiver that is installed into the cover. The mechanism will allow the cover to be replaced without indexing the cover to the frame. When locked, the mechanism will be flush with the frame surface, minimizing the potential for the cover to be dislodged. The bolt used to secure the cover is available in many configurations and can only be turned with a socket provided by the manufacturer. The U.S. Government will select the bolt configuration. A disposable tamper-evident plastic cap snaps into the lock body covering the recessed bolt head, keeping dirt and debris out of the bolt area. An alternative means of securing the maintenance hole utilizes an inner, water resistant cover that can be locked by a General Services Administration (GSA)-approved, changeable combination lock. The U.S. Government will provide the locks.

c. Sump – A sump will be cast into the floor of the maintenance hole. The floor will slope toward the sump to provide drainage from all areas into the sump. The sump will be approximately 330 mm x 330 mm (13 in x 13 in), or a 330-mm (13-in) diameter circle, and will be 100 mm (4 in) deep, covered with a removable perforated or punched plate to permit drainage. The cover will be fastened to the housing by a chain, rope, or hinge.

d. Pulling-in Irons – Cable pulling-in irons will be installed on the wall opposite each main conduit entrance location, 90-230 mm (3-1/2 to 9 in) from the floor of the maintenance hole and in line with the conduit entrance. The pulling-in irons will be placed and embedded during the construction of the maintenance hole wall.

e. Grounding in Maintenance Holes – All new maintenance holes installed will include ground rods and bonding ribbon. The ground rod and bonding ribbon may only be omitted when the following conditions apply:

1) A maintenance hole is designed and constructed with an integral ground system with all ironwork bonded together.

2) The maintenance hole is identified as containing an integral ground system with a manufacturer's label.

3) U.S. Government approval is obtained.

All existing maintenance holes that require new splices, or where existing splices are opened, will be bonded and grounded. If no bonding ribbon and ground rod exist, then they will be installed and all other existing splice cases will be bonded and grounded. New cables installed in maintenance hole and conduit systems will be bonded and grounded a minimum of every 305 m (1,000 ft). In accordance with RUS 1751F-802 and NEC, Article 250, the resistance for OSP grounding will be nominally 25 ohms (Ω).

f. Ground Rod – A 20-mm x 3-m (3/4-in x 10-ft) diameter galvanized or copper clad steel ground rod will be installed in the floor of each new maintenance hole. Copper clad steel is the preferred ground rod medium. One hundred millimeters (4 in) of the rod, plus or minus 1.3 mm (1/2 in) will extend above the finished floor level. The rod will not enter the maintenance hole more than 80 mm (3 in) or less than 50 mm (2 in) from the vertical surface of the adjacent wall. All maintenance hole splices will be bonded to the maintenance hole ground. In existing maintenance holes, new ground rods and/or bonding ribbon will be designed at each splice location if none presently exists. The ground rod will be installed and bonded IAW the NEC, Article 250.

g. Bonding Ribbon – A bonding ribbon will be installed in all new maintenance holes. The bonding ribbon will be attached to all rack anchors and be pre-cast into the maintenance holes. The bonding ribbon will be installed around the interior of the maintenance hole so that splice cases can be bonded to it.

h. Hardware – A minimum of five cable racks, each containing at least 47 hook spaces mounted vertically, will be provided on each long wall. Two of the cable racks will be installed flush to the wall and three with standoffs to create splice bays (Figure C-4 [Figure C-9 for Europe]). End wall maintenance hole racks will be provided at the T-end of multi-directional maintenance holes. Corner racks will be provided at the in-line end of the maintenance hole. Offset-cable racks will set out from the wall a minimum of 3 in. Each cable rack will be equipped with hooks to support all existing or new cables. If there are no existing/new cables, each rack will be equipped with two cable hooks (minimum length 190 mm (7-1/2 in). All racks and hooks will be of galvanized metal. Figure C-4 (Figure C-9 for Europe) – Typical Maintenance Hole shows a typical rack installation.

i. Water Resistance – Reasonable efforts will be taken to prevent water from entering a telecommunications maintenance hole. The manufacturer's instructions for installing a maintenance hole will be followed. As a minimum, the following guidance will apply as long as it does not violate a manufacturer's recommendations or warranty. Additional requirements may be identified in the SOW/EDP.

1) A water resistant gasket or seal will be placed between the sections of pre-cast maintenance holes.

2) Water resistant gaskets or seals will be placed between the lid frames, collars, and maintenance hole tops.

3) The area around ducts penetrating the maintenance hole walls will be sealed with a permanent water-resistant material.

4) Vacant ducts will be sealed with a mechanical, screw-type, reusable duct plug.

5) Ducts containing cables will be sealed with water-blocking foam or other recommended sealants designed for this purpose.

6) Ducts containing innerduct or multi-cell fabric mesh innerduct will be sealed with manufacturer's recommended materials or methods.

3.6.1.4 Duct Assignment and Cable Racking

Duct assignment and cable racking will be engineered and installed IAW the *AT&T Outside Plant Engineering Handbook*, August 1994, Practices 632-305-215 and 919-240-300, and standard drawings, unless otherwise directed in the site-specific SOR/EDP. Copper cables will be racked to the maintenance hole sidewalls in such a manner to make the best use of the wall space available. When placing cables, care should be taken to avoid blocking ducts in the sidewalls or access to splice cases.

The FOCs will be engineered with enough slack so that a 6-m (20-ft) service loop can be installed in each pull through maintenance hole or a 15-m (50-ft) splice loop on each cable installed into a splice case. The service and splice slack will be coiled and lightly secured in loops that do not violate the bending radius, and will be placed in the maintenance hole in such a manner that the cables are out of the way and not wrapped around other cables.

3.6.1.5 Stencil

All new maintenance holes will be stenciled with a number designated by the DOIM.

3.6.1.6 Depth of Cover

A minimum of 600 mm (24 in) of top cover will be provided above the top of the maintenance hole.

3.6.2 Hand Holes

Hand holes are reinforced concrete units provided with a lid that permits internal access to the housed components. Hand holes are typically used as pull points for small diameter cables for building access. A hand hole will not be used in place of a maintenance hole or in a main conduit system. Hand holes will not be used for splicing cables without prior U.S.

Government approval. Telecommunications hand holes will not be shared with electrical installations. The minimum hand hole size is 1.2 m x 1.2 m x 1.2.m (4 ft x 4 ft x 4 ft). Larger hand holes (i.e., 1.2 m x 1.8 m x 1.2 m) are acceptable. Hand holes installed where vehicle traffic may be present will be load rated as H-20 and will be equipped with round maintenance hole lids.

3.6.2.1 Accessories

Each new hand hole will be equipped with a lid, pull irons, cable racks, and hooks designed for use in telecommunications systems. Cable hooks will be placed to support the weight of the cable.

3.6.2.2 Stencil

All new hand holes will be stenciled with a number designated by the DOIM.

3.6.3 Cable Vault

A schematic of an MDF and cable vault is provided in Figure C-6 (Figure C-11 for Europe) – MDF and Cable Vault Schematic.

3.6.3.1 Size

The cable vault will be sized to provide for future projected growth. As a minimum, it will extend the entire length of the MDF.

3.6.3.2 Layout

A center rack will be provided for the splicing of the tip cables to the OSP cables. However, wall racking, if cited in the site-specific SOR/SOW, is allowable for small to medium central offices. The vault will be designed to allow ample space for splicing of the cables. For planning, a typical vault splice is 300 m x 900 m (1 ft x 3 ft).

3.6.4 Conduit/Duct

Underground conduit structures consist of pathways for the placements of telecommunications cable between points of access. Underground installation of ducts/conduits will be achieved by trenching, boring, or plowing.

a. Examples of conduit types include the following:

   - Encased Buried (EB)-20 – for encasement in concrete
   - EB-35 – for encasement in concrete
   - DB-60 – for direct burial or encasement in concrete
   - DB-100 – for direct burial or encasement in concrete
   - DB-120 – for direct burial or encasement in concrete
   - Rigid Nonmetallic Conduit Schedule 40 – for direct burial or encasement in concrete
   - Rigid Nonmetallic Conduit Schedule 80 – for direct burial or encasement in concrete
   - Multiple Plastic Duct (MPD) – for direct burial or installation in conduit
   - Rigid Metallic Conduit – for direct burial or encasement in concrete
   - Intermediate Metallic Conduit – for direct burial or encasement in concrete

- Fiberglass Duct – for direct burial or encasement in concrete
- Innerduct Polyethylene (PE) – for direct burial or installation in conduit
- Innerduct Polyvinyl Chloride (PVC) – for direct burial or installation in conduit
- High Density Polyethylene (HDPE) – for directional drilling
- EB-20 and DB-60 conduit will meet National Electrical Manufacturers Association (NEMA) Standard TC-6
- EB-35 and DB-120 conduit will meet NEMA Standard TC-8
- Schedule 40 and Schedule 80 rigid nonmetallic conduit will meet NEMA Standard TC-2

b. Nonmetallic conduits will be encased in concrete of minimum 20,700-kPa (3,000-PSI) compressive strength where vehicular traffic (i.e., automotive, railway) is above the pathway, or where a bend or sweep is placed.

c. Spacers will be used to properly support ducts, that are to be concrete encased, and will be installed IAW the manufacturer's specifications. If the manufacturer's specifications are unknown, a spacer will be installed a minimum of one spacer every 3 m (10 ft). Ducts supplied in 6.1-m (20-ft) lengths require spacers every 1.5 m (5 ft). The duct will not be damaged, cracked, or crushed prior to or during installation. Conduit systems not encased in concrete will be installed in layers with backfill installed around and between the ducts. Spacers may be used where conduits are not encased in concrete to provide integrity of orientation. Construction vehicles will not be driven over DB conduits.

d. Ensure the integrity of the orientation of the duct bank between maintenance holes. Do not allow the ducts to twist or tangle between maintenance holes.

3.6.4.1 Ducts Installed in Trenches

The type of duct for new installation will be PVC, Schedule EB, DB, or Schedule 40. Schedule EB duct will be used only if the duct is encased in concrete. Schedule DB or Schedule 40 duct will be used for applications where the duct is DB or encased in concrete.

3.6.4.2 Joints and Connectors

Ducts will be joined in such a manner as to be soil tight. Joints will form a sufficiently smooth interior surface between joining sections so that cables will not be damaged when pulled past the joint. Joints between dissimilar types of ducts (PVC, HDPE, galvanized steel pipe (GSP), EB, DB, etc.) will use the appropriate connectors designed for the purpose of providing a seal between the ducts and preventing damage to cables pulled through these joints.

3.6.4.3 Bends and Sweeps

Accomplish changes in direction of runs exceeding a total of 10^{o}, either vertically or horizontally, by long sweeping bends having a minimum radius of 7.62 m (25 ft). Long sweeps may be made up of one or more curved or straight sections and/or combinations thereof. Bends made manually will not reduce the internal diameter of the conduit. There will be no more than the equivalent of two 90^{o} bends (180^{o} total) between pull points, including offsets and kicks with a curvature radius of less than 30 m (100 ft). Back-to-back 90^{o} bends will be avoided. The following definitions are explained below:

a. Ninety-Degree Bend – Any radius bend in a piece of pipe that changes direction of the pipe 90^o.

b. Kick – A bend in a piece of pipe, usually less than 45^o, made to change the direction of the pipe.

c. Offset – Two bends usually having the same degree of bend, made to avoid an obstruction blocking the run of the pipe.

d. Ninety-Degree Sweep – A bend that exceeds the manufacturer's standard size 90^o bend (e.g., 600 mm (24 in) is standard for 100-mm (4-in) conduit).

e. Back-to-Back 90-Degree Bend – Any two 90^o bends placed closer together than 3 m (10 ft) in a conduit run.

Where the radius is less then 12-m (40-ft), 4.6-m (15-ft), radius-manufactured bends must be used. If possible, the entire change in direction should be made with a single arc of 4.6-m (15-ft) radius. Manufactured bends may be used on subsidiary/lateral conduits at the riser pole or building entrance. Manufactured bends will have a minimum radius of 10 times the internal diameter of the conduit IAW NEC Chapter 9 and ANSI/TIA/EIA-758.

Bends and sweeps will be concrete-encased to protect the duct from the pressures developed while pulling cables. Where a duct enters a building and sweeps up through a floor slab, galvanized RSC will be used. For ducts transitioning from the lower duct window of a maintenance hole to the nominal trench depth, the transition will be accomplished in no less than 9.1 m (30 linear ft) from the maintenance hole in order to reduce the radius of the bends. The duct should be concrete-encased in the transition area.

3.6.4.4 Section Lengths

The section length of conduit will not exceed 183 m (600 ft) between pulling points in main conduit runs without U.S. Government approval. The section length of subsidiary duct is limited mainly by the size of the cable to be pulled into it and the number of bends it will contain. Table 2 lists the maximum section lengths.

Table 2. Maximum Length of Subsidiary Conduit Containing Bends

Cable Diameter mm (in)	Limited Lengths of Duct*		
	One 90 Degree Bend (m) (ft)	Two 90 Degree Bends (m) (ft)	Three 90 Degree Bends (m) (ft)
25.4 (1.0)	182 (600)	107 (350)	76.2 (250)
30.5 (1.2)	152 (500)	91.4 (300)	
35.6 (1.4)	122 (400)	83.8 (275)	
40.6 (1.6)	107 (350)	76.2 (250)	
45.7 (1.8)	91.4 (300)	61 (200)	
56 (2.2)	76.2 (250)	45.7 (150)	
66 (2.6) or greater	61 (200)	45.7 (150)	

*Bends may be vertical or horizontal. Reverse curves and the use of three 90^o bends should be avoided.

3.6.4.5 Minimum Duct Bank Sizing

The minimum sizing for new duct banks is listed below. The total number of conduits required will be determined, including existing conduits, conduits installed by this effort, and known future requirements, along with 50 percent of this total for spares.

a. Ducts between the cable vault and the first maintenance hole will be based upon the size of the switch, the number of outside cable pairs served from the switch location, the fiber optic requirements, and future growth.

b. A main duct run includes the maintenance holes and ducts from a DCO or node and provides the pathways for large feeder cables and/or core FOCs. New main duct runs will consist of a minimum of 6-way, 4-in duct banks. In Europe, at least 125-mm ducts will be used. One of the ducts will be equipped with four integrated 30-mm (1.19-in) (minimum) sub-ducts or four 51-mm (2-in) conduits connected into an assembly.

c. A lateral duct run is defined as a minor branch run from the main duct run between maintenance holes. New lateral duct runs will be a minimum of four-way, 4-in duct banks. In Europe, at least 125-mm ducts will be used. One of the ducts will be equipped with four integrated 30-mm (1.19-in) (minimum) sub-ducts or four 51-mm (2-in) conduits connected into an assembly.

d. Entrance ducts are defined as ducts from a maintenance hole or hand hole to an end user building (EUB). New EUB entrance ducts will be a minimum of two-way, 4-in duct banks. In Europe, at least 125-mm ducts will be used. One of the ducts will be equipped with four integrated 30-mm (1.19-in) (minimum) sub-ducts or four 51-mm (2-in) conduits connected into an assembly.

e. Entrance conduits in minor buildings, as listed in the site-specific SOR/EDP, will be a minimum of one-way, 100-mm (4-in) ducts if the entrance cables are less than 25-mm (1-in) diameter and if less than 40 percent of the duct area will be used.

f. The lengths of ducts entering buildings or terminating at riser poles will not be placed longer than the values specified in Table 2 without prior U.S. Government approval.

g. IAW the NEC, cables entering a building from the outside and not rated for inside plant use may not extend beyond 15 m (50 ft) from the cable's point of entry into the building. The point of entry is defined as the place where the cable penetrates the exterior wall or floor. The point of entry may be extended beyond the 15-m (50-ft) limitation by using either rigid metal conduit (RMC) or intermediate metal conduit (IMC), both of which will be grounded. The EMT is not an acceptable media for extending the point of entry into a building. Reference the NEC, Sections 770.50 and 800.50.

3.6.4.6. Duct Installation Guidelines

a. Depth of Cover – At least 600 mm (24 in) of cover is required above the top of the duct bank. At least 457 mm (18 in) of cover is required under roads or sidewalks (if duct is concrete-encased). For ducts installed in solid rock, the cover will consist of at least 150 mm (6 in) of concrete. If rock is encountered below grade, the minimum cover above the concrete-encased duct will be 300 mm (12 in). See Figure C-3 (Figure C-8 for Europe) – Conduit Placement/Cut and Resurface for details. The cover or fill will be compacted IAW Appendix A.

b. Trench Width – The contractor will engineer the trench width to the minimum width required to support the size of the duct bank being installed. For installing ducts, the trench width depends on the number of ducts, size of ducts, arrangement of ducts, and space around ducts (at least 50 mm [2 in]). Additional width may be required to work in deep trenches or with large count duct banks. Shoring of walls or sloping will be performed as required by OSHA and/or local requirements. The trench width for DB conduit will be wide enough to permit tamping of dirt on the sides of the conduit formation. See Figure C-3 (Figure C-8 for Europe) – Conduit Placement/Cut and Resurface for details.

c. Concrete Encasement – The duct system will be concrete-encased in all main cantonment areas. At a minimum, the duct system will be encased under all traffic areas, where any bend/sweep exceeds 10^{o}, in any direction, and in any stream/drainage area subject to washing out. Concrete-encased duct, galvanized RSC, or pipe casings will also be placed under all paved road surfaces and certain heavy traffic non-surfaced roads as documented in the site-specific SOR/EDP. The encasement/pipe will be extended a minimum of 1.8 m (6 ft) beyond the roadbed for all road crossings. The contractor will use only one brand of Portland cement that conforms to ASTM C 150. The concrete will be a wet type mix and placed in such a manner as to ensure the concrete completely surrounds all ducts and that no air or voids are trapped in the mix. (Dry bags of a ready mix type cement that has not been mixed with water and just dumped in the trench is not acceptable.) The contractor will obtain the signature of the on-site U.S. Government QC/QA representative, signifying the acceptability of the duct placement and spacing, prior to pouring any concrete over the duct. Concrete used to encase conduits will be a minimum 17,220 kPa (2,500 PSI) compressive strength.

d. Duct Placement – New ducts will be swept down and installed in the lowest available duct positions within the lowest available duct window in the maintenance hole. Additional ducts required in the future will be placed on top of the existing ducts. Ducts placed under this project will not prevent placement of future ducts in the upper duct positions. Conduits will terminate in bell ends or duct terminators at the point of entrance into the maintenance holes and buildings.

e. Rerouting of Existing Ducts – Existing ducts will be joined to new maintenance holes (pre-cast or cast-in-place) by rerouting the designated ducts from the demolished or abandoned maintenance hole to the new maintenance hole. Rerouting will begin far enough back from the old maintenance hole, at least 30 ft, to allow for standard bending radius and pulling tension. Continuity of operations on the affected cables will be maintained during the duct rerouting actions.

f. Reinforcement of Existing Ducts – New ducts installed to reinforce an existing duct bank will be placed above the existing duct bank if the minimum top cover of 600 mm (24 in) can be maintained. If there is not sufficient top cover available, the new duct will be placed beside the existing duct bank.

g. Pull String/Rope/Tape – Once ducts have been mandrelled to verify their integrity, a pull string, pull rope, or pull tape rated at not less that 890-newton (N) (200-lb) tensile strength will be installed in each new conduit and innerduct/sub-duct. A minimum of 1.5 m (5 ft) will be provided at each end of the conduit. The string/rope/tape will be coiled and secured at each end in such a manner as to prevent it from being accidentally pulled back into the duct.

h. Plugs – All ducts, sub-ducts, and, innerducts, whether main or subsidiary runs, will be plugged using screw-type duct plugs in maintenance holes, hand holes and building entrances. Foam sealant is not acceptable in a building.

i. Duct Seals – The area between the entrance conduits and the penetrated floors and/or walls of a building or maintenance hole will be sealed to be waterproof or fire-stopped as appropriate. Use of hydraulic cement between the duct and wall is acceptable for waterproofing the duct entry point.

3.6.5 Galvanized Rigid Steel Conduit and Steel Casings

For road crossings that do not use the cut and restore method, RSC or steel pipe casings will be used as specified in the site-specific SOR/EDP. The RSC and steel casings will be placed under the highway in a manner that does not damage the conduit or casing.

3.6.5.1 Size and Fill

The contractor will use a steel casing, a minimum of 300-mm (12-in) diameter with a minimum wall thickness of 5 mm (3/16 in), for pushing under commercial railroad crossings and for multiduct conduit runs under non-commercial railroad beds. The steel casing will have an inner diameter, a minimum of 100 mm (4 in) wider than the outer diameter of the conduit formation (with spacers) that will be placed within the casing. Spacers will be used to support ducts installed within the casing. A single 100-mm (4-in) diameter RSC can be installed under non-commercial railroad beds in single conduit applications. After the duct installation, the casing must be filled with fine sand (blown in with air pressure) or slurry and sealed on both ends with at least a 75-mm (3-in) thick concrete wall. Installation of the fill will be done in such a manner so as to not damage or deform the ducts. See Figure C-3 (Figure C-8 for Europe) – Conduit Placement/Cut and Restore for details on railroad crossings.

3.6.5.2 Materials

Galvanized RSC used as telecommunications conduit must be made from soft, weldable quality steel that is suitable for bending. The hot-dipped zinc coating (galvanization) placed on the interior of the conduit must be smooth and free from blisters, projections, and other defects. The weight of the zinc coating on the interior and exterior surfaces should not be less than 61 grams per 1,000 square centimeters (cm^2) (two ounces per square foot [ft^2]) of total coated surface. Steel pipe casings will comply with ASTM A-139 Grade B or ASTM A-252. Pipe ramming will be done IAW TTC Technical Report #2001.04.

3.6.6 Split Duct

Split ducts are designed to be placed around existing cable, such as when repairing conduit, capturing existing conduit, or for use on a long DB cable run where the cable is placed in the open duct while the duct and trench are still open. Split duct will be used for crossing roads in DB cable runs only after one-fifth of the cable reel length for cables greater than 25 mm (1 in) in diameter, and one-third of the cable reel length for cables less than 25 mm (1 in) in diameter, is used in each unspliced span. The split duct under road crossings will be concrete-encased. Normal conduit will be used in all other areas.

3.6.7 Rod/Mandrel/Slug/Clean Ducts or Conduits

3.6.7.1 Rod Duct

Rodding a duct entails inserting or pushing a rod into the duct to:

- Determine the length of the duct
- Locate the other end of the duct
- Determine if the duct is usable or blocked
- Insert a pull string in the duct

3.6.7.2 Mandrelling

Mandrelling a duct consists of pulling a test mandrel or slug through the duct to insure that the duct diameter is intact and ready for the installation of cables. Mandrelling can also be used to clean any mud, sand, or dirt out of the duct. The mandrel's diameter, 13 mm (1/2 in less than the duct's inside diameter, depends on the type and size of the ducts. New ducts in main and subsidiary duct runs will be mandrelled with a test mandrel (non-flexible) or slug that is approximately 300 mm (12 in) in length and 13 mm (1/2 in) less than the duct inside diameter. The test mandrel will be used to verify the integrity of the duct joints, to test for out-of-round duct, and to verify that sweeps are not so severe as to preclude the placement of large diameter cables. The 300-mm (12-in) test mandrel will not pass through ducts with 90^{o} sweeps. A 150-mm (6-in) length test mandrel may be used to test duct runs to buildings or riser poles. Flexible mandrels, wire brushes, rubber duct swabs, leather washer duct cleaners, etc., may be used to clean the ducts.

3.6.7.3 Existing Ducts

Existing vacant ducts that are to be used in new cable installations, as defined in the site-specific SOR/EDP, will be cleaned and tested with a test mandrel to detect any obstructions, collapsed ducts, or duct inconsistencies. The contractor will repair damaged ducts if approved by the U.S. Government. The duct should not be mandrelled if existing cables are in the duct.

3.6.8 Sub-duct/Innerduct/Multiduct/ Fabric Mesh Innerduct

Innerduct, sub-duct, multiduct, or fabric mesh innerduct is typically a nonmetallic pathway and may be placed within or in place of a duct to subdivide the space and facilitate initial and subsequent placement of multiple cables in a single duct space. All subdivided spaces will have a pull rope or pull tape installed. The PVC sub-ducts that do not have cables installed will be plugged with a screw-type duct plug. A minimum of one out of every four new ducts will be subdivided with innerduct, sub-duct, multiduct, or fabric-mesh innerduct.

3.6.8.1 Sub-duct

A sub-duct will provide the equivalent of four each 32-mm (1-1/4-in) diameter (minimum) conduits in the space that is normally occupied by a 100-mm (4-in) conduit. The sub-ducts will be held in relation to each other with spacers.

3.6.8.2 Multiduct

Multiducts are pre-manufactured duct systems that are equipped with four fully integrated 30-mm (1.19-in) (minimum) sub-ducts.

3.6.8.3 Innerduct

Innerducts are smaller diameter ducts, typically 25-mm (1-in) diameter (minimum), that are placed inside existing ducts. The innerduct will consist of a minimum of three each, 25-mm (1-in) PE ducts installed inside a single, 100-mm (4-in) duct. Innerducts will be used in existing conduit systems, in RSCs, or in split RSCs. Rigid-type innerducts with pull strings will be provided.

3.6.8.4 Fabric-Mesh Innerduct

Fabric-mesh innerducts are made of a stiff, fabric-mesh cloth that has been folded and sewn in such a way as to create individual cells through which a cable may be installed without tangling with cables in other cells. Fabric-mesh type innerducts may be used as approved by the U.S. Government and will be limited to a maximum of six cells, unless otherwise approved by the U.S. Government. Multi-cell fabric mesh will have an uninterrupted, shared, sewn spine to prevent twisting. Conduit formations will not be undersized based on the increased modularity of the fabric-mesh innerduct. The FOCs will not be "home run" from buildings to serving nodes because of the increased modularity of fabric type innerducts.

3.6.9 Directional Boring/Horizontal Directional Drilling (HDD)

The HDD is a trenchless method for installing ducts for underground cable. Ducts are installed by drilling or boring a path through the soil and placing the ducts within this path. The vertical profile of the bore alignment is typically in the shape of an inverted arc.

3.6.9.1 Restrictions

Ducts installed using the HDD method under roads will be deep enough to clear existing utilities and meet H-20 load ratings. The ducts placed by HDD will not directly enter a maintenance hole but will be attached to conduit stub-outs that extend a minimum of 3 m (10 ft) from the maintenance hole. The HDD may be done in areas approved by the U.S. Government or as stated in the site SOR/EDP. The maximum radius curvature of a bore is limited to the maximum conduit diameter times 30.5 m per 25 mm (100 ft per in).

3.6.9.2 Methodology

The HDD is a multi-stage process consisting of drilling a pilot bore along a predetermined path and then pulling the desired product back through the drilled space. When necessary, enlargement of the pilot borehole is accomplished by back reaming. In order to minimize friction and provide a soil-stabilizing agent, a drilling fluid is introduced into the annular space created during the boring operation. The rotation of the bit in the soil wetted by the drilling fluid creates slurry. This slurry acts to stabilize the surrounding soil and prevents collapse of the borehole and loss of lubrication.

3.6.9.3 Pits

In order to confine any free flowing slurry at the ground surface during pull back or drilling, sump areas will be created to contain any escaping slurry that might damage or be hazardous in surrounding areas. All residual slurry will be removed from the surface and the site restored to preconstruction conditions. Excavation for entry, recovery pits, slurry sump pits, or any other excavation will be carried out as specified in Appendix A. Sump areas are required to contain drilling fluids.

3.6.9.4 Drilling Fluids

A mixture of bentonite clay or other approved slurry and potable water will be used as the cutting and soil stabilization fluid. The viscosity will vary to best fit the soil conditions encountered. Water used will be clean and fresh, with a minimum of a 6-pH level. No other chemicals or polymer surfactant (surface-active substance) are to be used in the drilling fluid without the written consent of the U.S. Government and after a determination is made that the chemicals to be added are environmentally safe and not harmful or corrosive to the facility. When drilling in suspected contaminated ground, the drilling fluid will be tested for contamination and disposed of appropriately. Any excess material will be removed upon the completion of the bore.

3.6.9.5 Tracking

The contractor will provide a method of locating and tracking the drill head during the pilot bore and will ensure the proposed installation is installed as intended. All facilities will be installed in such a way that their location can be readily determined by electronic designation after installation. For non-conductive installations, this will be accomplished by attaching a continuous conductive material externally, internally, or integrally with the product. A copper wire line or a coated conductive tape may be used for this conductive material.

3.6.9.6 Duct Installed by Directional Boring

Materials must meet or exceed the following standards:

Material Type	Standard
PE	ASTM D 2447
HDPE	ASTM D 2447
	ASTM D 3350
	ASTM D 2239

A PVC conduit with mechanical connectors made for the purpose of directional drilling may be used with U.S. Government approval.

3.6.9.7 Joints

An HDD conduit will be placed with soil tight joints. Joints between dissimilar types of ducts (PVC, HDPE, GSP, EB, DB, etc.) will use the appropriate connectors to provide a seal between the ducts and to prevent damage to cables pulled through these joints.

3.6.9.8 Restoration

The site will be restored after installation of the conduit is complete. The work site will be cleaned of all excess slurry remaining on the ground. The contractor performing the boring is responsible for removal and final disposition of excess slurry or spoils as the conduit is introduced. Excavated areas will be restored IAW Appendix A. The cost of restoring damage caused by heaving, settlement, escaping drilling fluid (fracout), or the directional drilling operation to roads, parking lots, pavements, curbs, sidewalks, driveways, lawns, storm drains, landscapes, and other facilities will be borne by the contractor.

3.6.10 Conduit Rehabilitation

The designer may consider rehabilitation of existing conduits as an alternative to installation of new concrete-encased conduit where the cost, location, or magnitude of the construction effort is prohibitive. The conduit rehabilitation must be IAW standard practices of ASTM 1216, using ASTM-compliant products and processes. The rehabilitated conduit should have an inner diameter sufficient to support the intended cable installation and minimal growth. The designer should note that the inner diameter of existing conduits will be reduced by the application of resin-impregnated tubes for rehabilitation.

3.6.10.1 Survey Requirements

Conduits intended as candidates must be inspected to ensure that rehabilitation is feasible. ASTM 1216 states that conduits must be cleaned and inspected prior to the installation of the resin-impregnated tube. Therefore, the survey must verify that cleaning is sufficient to prepare the conduit for rehabilitation. The survey should include inspection from maintenance hole or building entrance end points, either visually or by a conduit video system on both ends of the conduit. A record of the video inspection should be maintained after the survey. Collapsed or crushed ducts should not be used for rehabilitation.

3.6.10.2 QA Inspection and Acceptance

Restored conduits should have a friction coefficient that meets ASTM 1216. The conduit should be inspected by a conduit video system to verify that it has been restored to a usable system that meets the minimum requirements outlined in the underground conduits section of this guide, with the exception of inside diameter.

3.7 DB Cable Installation

The DB cable will be engineered and installed IAW RUS Bulletins 1751F-640, 641, and 642.

3.7.1 Cable Type

Rodent-protected cable will be used for all buried applications, unless otherwise specified in the site-specific SOR/EDP.

3.7.2 Warning Tape

See Paragraph 3.4.6 for the details on warning tape.

3.7.3 Warning Signs

Buried cable warning signs or route markers will be provided no less than every 76 m (250 ft) or at each change in route direction, on both sides of street crossings, on pipelines, and on buried power cables. Color-coded warning signs or markers will be orange in color.

3.7.4 Plowing

Plowing will be used in range environments or other areas where there are no significant obstacles and where cable runs typically exceed 305 m (1,000 ft) between splices. The site-specific SOR/EDP will identify areas in which plowing is deemed feasible.

3.7.5 Trenching

3.7.5.1 Backhoe Trenching

Trenching with a backhoe will be done only for short distances (i.e., maintenance hole to building). The contractor will hand dig at all existing maintenance hole locations, building entrance points, utility crossings, through tree roots, under curbs, etc.

3.7.5.2 Trencher Trenching

A maximum trench width of 300 mm (12 in) will be used in DB applications done by a trencher. The contractor will hand dig at all existing maintenance hole locations, building entrance points, utility crossings, through tree roots, under curbs, etc.

3.7.6 Depth of Placement

3.7.6.1 Copper Cable

The depth of placement for a DB copper cable will provide a minimum top cover of 600 mm (24 in) in soil, 900 mm (36 in) at ditch crossings, and 150 mm (6 in) in solid rock (RUS Bulletin 345-150/RUS Form 515A).

3.7.6.2 Fiber Optic Cable

The DB FOC will be placed at a depth providing a minimum top cover of 1070 mm (42 in). In solid rock, the minimum top cover will be 150 mm (6 in).

3.7.6.3 Frost Considerations

In areas where frost heaving can be expected, the cable or wire should be buried below the frost line. Movement of OSP housings due to frost heaving can cause damage to the insulated copper conductors, optical fibers, or loss of shield and/or armor continuity. In areas where movement of OSP housings by frost heaving is encountered, the OSP housings should be installed on stub poles. The stub poles should be set below the frost line and IAW the requirements of RUS Form 515.

3.7.6.4 Other Considerations

The DOIM/DPW may have special depth requirements for certain areas (i.e., tank tracks, ranges, etc.), which will be provided in the site-specific SOR/EDP.

3.7.7 DB Cable Splicing

Buried splices will be engineered/installed as identified in the site-specific SOR/EDP only. For example, a buried splice may be used for the following conditions with U.S. Government approval:

- Electrical or Explosion Hazard (i.e., ammunition areas)
- Vehicular Hazard (i.e., motor pool areas)
- Security Hazard (i.e., within a high security compound)

Only splice cases specifically designed for a buried application will be used. All buried splices will be encapsulated. All other splices in a DB run will be placed in pedestals or maintenance holes. Encapsulation is not required in a pedestal.

3.8 Crossing Obstructions

3.8.1 Pavement Crossing

Cut and resurface is the preferred method to be used when crossing any paved area. Push/bore and/or directional boring will be used for special circumstances only as specified in the site-specific SOR/EDP. The preferred method of cut and resurface is the "T" cut. That is, the outer edge of the cut of the road surface is to extend six in beyond the edge of the trench on both sides. See Figure C-3 (Figure C-8 for Europe) – Conduit Placement/Cut and Resurface for placement details.

3.8.2 Range Road Crossing

For road crossings on ranges, concrete encasement will be extended a minimum of 6 ft beyond the edges of the roadbed.

3.8.3 Railroad Crossing

Push and bore with steel casings is the preferred method for railroad crossings. When multiple conduit formations are placed, a minimum of a 300-mm (12-in) diameter steel casing, with a minimum wall thickness of 5 mm (3/16 in), will be used. The casing will extend no less than 3.7 m (12 ft) beyond the centerline of the track or the outermost track if multiple tracks are crossed. In accordance with the NESC, the casing will be located no less than 1,270 mm (50 in) below the top of the rails. The casing should be no less than 900 mm (36 in) below the bottom of any crossed drainage ditch.

Directional boring will not be used to place conduits below commercial railroad beds. Directional boring is not the preferred method to place conduits below U.S. Government railroad beds. When required by the U.S. Government as stated in the SOR/EDP, directionally bored HDPE will be placed a minimum of 4.6m (15 ft) below the roadbed in typical soil. The conduits will be placed at a depth so that standard E-80 live and impact loads (119,500-kg/m (80,000-lb/ft), axle loads spaced on 1.5 m (5 ft) centers) will not produce more than 5-percent deflection in the proposed HDPE conduits.

3.8.4 Rocky Soil Crossing

Pushes will not be engineered for sites with rocky soil conditions. Boring will not be engineered for sites with rocky soil conditions without U.S. Government approval. Cut and resurface methods will be used to the maximum extent possible.

3.9 Aerial

Supporting documentation for aerial placement is available in RUS Bulletins 1751F-630 and 1751F-635. Aerial cable runs will be used only with U.S. Government approval in extenuating circumstances or for long runs outside of the cantonment area, as specified in the site-specific SOR/EDP.

3.9.1 Messenger Strand

The smallest messenger strand used for all new installations will be 6.6 m. A 2.2-m strand will be used only as an extension of existing 2.2-m strands. The FOC will be installed on its own messenger. Copper and fiber cables will not be lashed on the same messenger without U.S. Government approval. Figure-8 cable may be used; however, no additional cable will be lashed to it.

3.9.2 Guys and Anchors

Place new guys and/or anchors for each new messenger strand at each applicable location (cable turns, wind loading, cable ends, etc.). The down guy will be sized to the next larger strand.

3.9.3 Aerial Splices and Terminals

3.9.3.1 Fiber

Aerial fiber splices will not be used without U.S. Government approval. Fiber optic splices will be placed in a pedestal at the bottom of the pole.

3.9.3.2 Copper

Support all terminals and splices by direct attachment to a fixed object (pole, building, pedestal, etc.). The cable will not support devices. Pole-mounted and fixed-count terminals will be used. Terminals will be placed so that no single drop exceeds 152 m (500 ft) in length.

3.9.4 Water Protection

Weatherproof all outdoor connections by using weather boots or other approved methods. Form a rain-drip loop at all cable entrances into buildings at the point of ingress. Waterproof all building entrance points.

3.9.5 Horizontal Clearances for Poles/Aerial Cable

The following horizontal clearances, as specified in the *AT&T Outside Plant Engineering Handbook*, Practice 918-117-090, will be adhered to, unless otherwise directed by the site-specific SOR/EDP:

- Fire hydrants, signal pedestals – 1.2 m (4 ft)
- Curbs – 150 mm (6 in)
- Railroad tracks – 4.6 m (15 ft)
- Power cables less than 750 volts (v) – 1.5 m (5 ft) or more

3.9.6 Vertical Clearances for Aerial Cable

The following vertical clearances, as specified in the *AT&T Outside Plant Engineering Handbook*, Practices 627-070-015 through 017, and Practice 918-117-090, will be adhered to, unless otherwise directed by the site-specific SOR/EDP:

- Streets or roads – 5.5 m (18 ft)
- Driveways to residences and garages – 3 m (10 ft)
- Alleyways – 5.2 m (17 ft)
- Pedestrian walkways – 2.4 m (8 ft)
- Railroad tracks (measured from top of rail) – 8.2 m (27 ft)

3.10 General Cable Specifications

3.10.1 General Installation

Cables will be placed in such a manner as to avoid kinks and other sheath deformities.

3.10.1.1 Pulling Tension

When pulling cable into ducts, innerducts, or sub-ducts, the manufacturer's specified pulling tension will not be exceeded. A lubricant will be used in the amount specified by the lubricant manufacturer. The lubricant will be a pourable, water-based, slow-drying fluid that will not stress-crack the low-density PE and will not damage the cable jackets.

3.10.1.2 Evaluating Existing Cable/Testing New Cable

When the installation includes work on an existing cable, the contractor will test all affected pairs before completing any throws or splices. A list of the defective pairs will be submitted before the work proceeds. After the cable work has been completed, the contractor will test all affected cable pairs. The contractor will clear trouble on any existing pairs that were not on the original list.

3.10.1.3 Bending Radius

During installation, the minimum bend radius for non-gopher resistant OSP twisted-pair cable will be no less than 10 times the cable diameter; after installation, it will be no less than 8 times the cable diameter, or as specified by the cable manufacturer. The minimum bend radius for gopher-resistant OSP twisted-pair cable during installation will be no less than 15 times the cable diameter; after installation, it will be no less than 10 times the cable diameter, or as specified by the cable manufacturer (Reference TIA/EIA 758, Paragraph 6.1.4.4). The minimum bending radius for FOCs during installation will be no less than 20 times the outside diameter of the FOC, or as specified by the cable manufacturer, and after installation will be no less than 15 times the cable diameter (Reference TIA/EIA 758, Paragraph 6.3.6).

3.10.2 Cable ID/Cable Tags

Cable tags will be installed at all termination points (terminals) and splices, including house cables. In maintenance holes, all new and existing cables that are part of the project will be tagged/retagged between the splice and the wall and on both sides of a splice loop or maintenance loop. One tag is required for a copper cable pull-through, and two tags are required for a FOC pull-through.

a. To identify a copper cable, size + type **and** cable ID (ID) + count are needed.

b. Cable sizes will be identified with an abbreviation. For example, a 1,200-pair cable will be identified as P12-24PF. All cables with fewer than 25 pairs will include an "X".

- 6-pair = P6X-24PF
- 12-pair = P12X-24PF
- 18-pair = P18X-24PF

c. To identify a 900-pair, 24-AWG copper cable:

- P9-24PF = size and type
- 03, 1-900 = cable number and count

(Only **existing** cable is identified with a "CA" prefix.)

d. To identify two different cables under the same sheath:

- P18-24PF
- 07, 1-1,500 + T1, 1-300

e. The FOCs will be identified with cable ID + count **and then** size + type.
- F 12, 1-72 = cable number and strand count
- 12 SM = type of cable

f. To identify a 10-pair, 0.6 mm European copper cable:
- 10x2x0.6 = size and type
- 01, 1-10 = cable number and count

g. To identify an 800-pair, 0.6 mm European copper cable:
- 800x2x0.6 = size and type
- 05, 1-800 = cable number and count

3.10.3 Copper Specifications

3.10.3.1 Telephone Cable Requirements

The contractor will ensure that all cable used in North America is Underwriters Laboratory (UL)-listed and meets the specifications of Telcordia Document, GR–421–CORE, *Generic Requirements for Metallic Telecommunications*, December 1998. Cables specified for use in Europe may not meet UL or Telcordia specifications.

3.10.3.2 European Telephone Cable Requirements

All multi-pair copper cable installed between buildings will be waterproof, IAW DIN VDE 0815 and 0816, *Wiring Cables for Telecommunications and Data Processing Systems.* The copper conductor size will be 0.6 mm diameter. Commercially available industry standard cables will be type A-02YSOF(L)2Y...x2x0.6 ST III BD (the "…" denotes the pair count).

a. The conductors in the cable will be color-coded. A basic color-coding scheme will be used to provide different color combinations on the insulation for each pair. The North American standard is based on a 25-pair group IAW Telcordia Documents (Tip: white, red, black, yellow, violet; Ring: blue, orange, green, brown, slate). The European standard is based on 10-pair groups as follows:

- The basic colors of wires of five starquads in the sub unit are red for the first quad, green for the second quad, grey for the third quad, yellow for the fourth quad, and white for the fifth quad
- Black rings code the individual wires
- The pilot unit bears a red helix
- All other units bear a white or transparent helix

b. Minimum Guaranteed Pairs: One hundred percent of pairs in a cable prior to installation and 99 percent of pairs after installation where it is not economical to recover the defective pair(s) will pass performance or acceptance tests. Defective pairs will be identified by location and type of fault. Splicing faults will be corrected.

3.10.3.3 Splices

a. Copper and FOC splicing will be performed IAW RUS Bulletin 1735F-401, *Standards for Splicing Copper and Fiber Optic Cable*, February 1995.

b. Cable will be spliced into one continuous length. All copper splices will be of the fold-back type to facilitate future work in the splice. Fiber cable will contain splice loops in trays IAW manufacturer's recommendations.

c. Completed splices will meet similar performance and mechanical specifications of a single cable of the same overall length.

d. Self-piercing electrical filled connectors will be used when splicing plastic-insulated conductors. The contractor will place and install connectors using a tool specifically designed to place those connectors. In North America, a 25-pair splicing module, 3M-type MS2 or equal will be used. The same modules will be used throughout the project and will be consistent with previously installed connectors to preclude a requirement for a variety of installation tools. B-wire connectors will not be used. In Europe, a 10-pair splicing module system is used.

e. Binder group integrity will be maintained.

f. All dead pairs in a copper cable will be spliced through if the size of the continuing cable will allow a clear and cap at the end. Only UL-listed material will be used when capping cable pairs.

g. All underground and buried splice cases will use encapsulant-fillable closures and will be filled with encapsulant upon completion of the splice IAW RUS Bulletin 345-72 (PE-74). Cable sheaths will be bonded at all cable splices with bonding harnesses to assure sheath continuity.

3.10.3.4 Cable Count Assignment

When assigning cable counts, the center of the cable will be the last pairs assigned on a cable route. The upper or higher cable pair counts will be used first. Therefore, the highest pair count in a cable will be located closest to the switch location, and the lowest pair count will be farthest away. Per the requirements of 6- and/or 12-pair terminals, Pair 13 (of a binder group) rather than Pair 1 will be spared.

3.10.3.5 Cable Gauge, Resistance Design

The cable gauge will be 24-AWG (0.6 mm in Europe), unless otherwise specified in the site-specific SOR/EDP.

3.10.3.6 Loading

a. Analog sets/circuits exceeding 5.49 kilometers (km) (18,000 ft) will require U.S. Government approval. If approved, these sets/circuits will be loaded.

b. When loading cables, H88 loading will be used 914 m (3,000 ft) from the switch location/digital loop carrier for the first load (including calculations for tip cables, jumper wires, etc.) and every 6,000-sheath ft thereafter. End sections will be greater than 914 m (3,000 ft) and less than 3.66 km (12,000 ft). End sections include all drops and station wire.

c. Build-out capacitors will be designed on trunk circuits between switches for placement between load points for distances shorter than 1.83 km (6,000 ft) between loads or between loads and end sections.

d. Pairs for any data circuits will not be loaded.

e. If digital or data sets are being used for the telephone system, these pairs will not be loaded.

3.10.4 Fiber Specifications

3.10.4.1 FOC Requirements

All specifications for FOCs will pertain to finished cable, not raw (uncabled) fiber. The FOC will conform to the specifications contained in RUS Bulletin 1753F-601, EIA/TIA-472, and EIA 472D. See Table 1 for the complete names of these references.

3.10.4.2 Fiber Types

All new OSP fiber cable will be single-mode. With U.S. Government approval, multimode fiber may be installed only in situations involving the extension of existing systems, as specified in the site-specific SOR/EDP, or in situations that cannot be adapted to single-mode cable.

a. Multimode Fiber – Fiber strands will have a nominal core/cladding diameter of 50/125 or 62.5/125 microns. All cabled multimode fibers will possess the following characteristics over the entire specified temperature range as shown in Table 3.

Table 3. Multimode Dual-Windowed Fiber Cable Characteristics

Function	Parameters for 50 microns	Parameters for 62.5 microns
Core/Cladding Diameter	50/125	62.5/125
Coating Diameter Microns	250	250
Core Eccentricity Maximum	6%	6%
Core Ovality	6%	6%
Refractive Index Delta	1%	2%
Core Diameter Microns	50 +/-3	62.5 +/-3
Cladding Diameter Microns	125 +/-3	125 +/-3
Numerical Aperture	0.20 +/-0.015	0.275+/-0.015
850 nm		
Maximum Attenuation dB/km	3.5	3.75
Minimum Bandwidth MHz-km	*****500	160
1,300 nm		
Maximum Attenuation dB/km	1.5	1.0
Minimum Bandwidth MHz-km	*****600	500
Cable Tensile Load Rating	******2,670 N (600 lb)	
Cable Minimum Bending Radius	15 x cable diameter under no load. **0-800 N (0-180 lb). 20 x cable diameter under load. **800-2,700 N (181-600 lb) (Note 2).	
*****Building/Breakout Cables (Tight Buffer). Minimum bandwidths do not apply to tight buffered, or breakout-type cables. The minimum bandwidths for tight-buffered cable are 400 MHz-km at both 850 nm and 1,300 nm. The index of refraction profile of multimode fiber will be near-parabolic graded index. ******Building/Breakout Cables (Tight Buffer). Tensile load rating and minimum bending radius do not apply to tight-buffered breakout-type cables.		

dB=decibel; km=kilometer; MHz=megahertz; nm=nanometer

b. Single-mode Fiber – Fiber strands will have a nominal core diameter of 8.3 microns. The cladding diameter will be 125 microns (+/-2 microns). All cabled single-mode fibers will have a maximum attenuation value of 0.35 dB/km for high grade at 1,310 nm over the entire specified temperature range as shown in Table 4. The fibers described in Table 4 are glass with a protective coating and an outer buffer tube. These fibers are placed in a cable of up to 192 fibers and are further protected by various layers as described in Paragraph 3.10.4.3. Plastic fibers will not be used.

Table 4. Single-Mode Dual-Windowed Fiber Cable Characteristics

Function	Parameters
Maximum Attenuation dB/km @ 1,310 nm	*****0.35
Maximum Attenuation dB/km @ 1,550 nm	*****0.25
Core Diameter Microns	8.3 (nominal)
Core Eccentricity	Less than or equal to 1.0 micron
Cladding Diameter Microns	125 +/-2
Coating Diameter Microns	250 +/-2
Mode Field Diameter Microns	8.8 +/-0.5
Zero Dispersion Range	1310 +/-010 nm
Maximum Dispersion Range	3.2 ps/nm - km (range 1,285 to 1330 nm) 19 ps/nm - km (range 1,550 nm)
Refractive Index	0.37%
Cable Tensile Load Rating	600 lb (Note 3)
Cable Minimum Bending Radius	******15 x cable diameter under no load. 0-800 N (0-180 lb) (Note 3). 20 x cable diameter under load. 800-2,700 N (181-600 lb).
*****Building/Breakout Cables (Tight Buffer). Maximum attenuations do not apply to tight buffered, breakout-type cables. Maximum attenuation for tight buffered cable is 1.25 dB/km @ 1,310 nm and 1.0 dB/km @ 1,550 dB/km. ******Building/Breakout Cables (Tight Buffer). Tensile load rating and minimum bending radius do not apply to tight buffered, breakout-type cables.	

ps=picosecond

c. Non-zero Dispersion-shifted Fiber (NZDSF) – The FOCs installed to support dense wave division multiplexing (DWDM) as identified in the SOR/SOW/EDP will be NZDSF optic cable when the distance exceeds 25 miles. The NZDSF cables will meet or exceed the recommendations of International Telecommunication Union-Telecommunication Standardization Sector (ITU-T) G.655, (03/2003) “Characteristics of a non-zero dispersion shifted single-mode optical fiber cable,” (Reference: Table 1/G.655-G.655A and Table 2/G.655-G.655B). Table 5 is an extraction of the ITU-T G.655. If the use of standard fiber versus non-zero dispersion-shifted fiber for the distance is in question, an analysis should be performed to determine which fiber will best support channel capacity for the distance the cable is to be installed.

Table 5. Non-Zero Dispersion-Shifted Single-Mode FOC Characteristics

Fiber Attributes		
Attribute	**Detail**	**Value**
Mode Field Diameter	Wavelength	1,550 nm
	Range of nominal values	8-11 μm
	Tolerance	± 0.7 μm
Cladding Diameter	Nominal	125 μm
	Tolerance	± 1 μm
Core Concentricity Error	Maximum	0.8 μm
Cladding Noncircularity	Maximum	2.0 %
Cable Cut-off Wavelength	Maximum	1,450 nm
Macrobend Loss	Radius	30 mm
	Number of turns	100
	Maximum at 1,550 nm	0.50 dB
Proof Stress	Minimum	0.69 GPa
Chromatic Dispersion Coefficient Wavelength Range: 1,530-1,565 nm	λ_{min} and λ_{max}	1,530 and 1,565 nm
	Minimum value of D_{min}	0.1 ps/nm·km
	Maximum value of D_{max}	6.0 ps/nm·km 10.0 ps/nm·km*
	Sign	Positive or negative
	D_{max} - D_{min}*	≤5.0 ps/nm·km*
Uncabled Fiber PMD Coefficient	Maximum	(see note).
Attenuation Coefficient	Maximum at 1,550 nm	0.35 dB/km
PMD Coefficient	M	20 cables
	Q	0.01 %
	Maximum PMD_Q	0.5 ps/√km
Note: An optional maximum PMD coefficient on uncabled fiber may be specified by cablers to support the primary requirement on cable PMD link design value (PMD_Q), if it has been demonstrated for a particular cable construction.		

* Values that apply to systems with minimum channel spacing of 100 gigahertz (GHz) or less.

λ=wavelength; μm=micrometer; D=Chromatic Dispersion Coefficient; GPa=gigapascal; M=cable sections; PMD=polarization mode dispersion; Q=small probability level

3.10.4.3 Temperature Range

Outdoor cables will have an operating and storage range of -40^o to +70^o Celsius (C). Indoor cables will have an operating and storage range of -20 to +70^o C. Cables will perform to their specified attenuation over the entire temperature range specified above. The attenuation will not vary by more than 0.2 dB/km for single-mode fibers and 0.5 dB/km for multimode fibers and will never exceed specified attenuation limits.

3.10.4.4 Fiber Cable Count Assignment

The FOC strand counts will be assigned in a similar manner as copper counts. The high number counts will be dropped first, and the strand one count will be the farthest from the serving node.

3.10.4.5 Use of Innerduct/Sub-duct/Fabric Mesh

For underground installation, each FOC will be installed in innerduct, fabric mesh, or sub-duct. The FOC will not be installed directly in a 4-in duct.

3.10.4.6 Splices and Power Budget

a. Mechanical or fusion splicing will be used for FOC only if the mean splice loss is less than or equal to 0.1 dB. No individual splice will exceed 0.3 dB.

b. IAW RUS Bulletin 1751F-642 for buried FOC plant, DB, filled, and/or splice cases installed in maintenance holes and hand holes will be used.

c. Loop-through splicing will be used in lieu of homeruns/dedicated cables to the serving location. In loop-through splicing, only the fiber strands breaking off from the main cable to enter a building are cut and spliced. The other fibers are not cut. The sheath is cut from the cable; the exiting fibers are cut and spliced; and the remaining fibers are folded back within the case (not cut) and then routed on.

3.10.4.7 Manufactured OSP Cable Assemblies

A manufactured OSP cable assembly shall be an FOC that is manufactured with connection points that allow for the connection of smaller FOCs to be attached without splicing in the field. The manufactured OSP assembly will be constructed in such a matter that the assembly can be installed either in a conduit, DB, or aerial system and will not be adversely affected by its environment any more than the traditional fiber cable products.

The use of manufactured OSP cable assemblies is permitted in OSP designs. The connection points should be selected to meet the overall design of the cable system.

3.11 Transfers, Cuts, and Throws

Cable transfers, cuts, and throws will be performed to maximize existing resources. All cables and terminals affected by cable count transfers will be retagged in the field to reflect the new changes.

3.12 Main Distribution Frame

The MainDistribution Frame (MDF) is the interface between the OSP cable and the switch cables. The iron framework of the MDF supports the horizontal blocks and vertical connectors. The MDF will be equipped with guard rails and end rails. The engineer will provide new vertical sections to support all newly installed cable if none are available. A minimum of 760 mm (30 in) of clearance around the frame is required for safety.

3.12.1 Horizontal Blocks

The horizontal blocks terminate the cables between the switch and the MDF. Each connection corresponds to a telephone number on the switch. The switch engineer will determine the number of horizontal blocks on the frame. All horizontal blocks will be stenciled to show the termination ID.

3.12.2 Vertical Connectors

The vertical connectors are mounted on the vertical side of the MDF. Each connector protects 100 or 200 pairs of the OSP cables. The connector is equipped with tip cables that are pre-terminated on the connector. The tip cables are routed from the MDF through the floor to the cable vault, or over the MDF to the wall, where they are spliced to the OSP cable. The connectors for the tip cables will be provided as either stub-up or stub-down as determined by the type of installation required. The vertical connectors protect the electronics in the DCO by providing lightning and surge protection. Each termination corresponds to a pair of the OSP cables. All OSP cable pairs will be terminated on connectors. All vertical connectors will be stenciled to show the cable number and the pair counts for all connectors on that vertical connector. All connectors will show the count terminated. A schematic showing the vertical side of the MDF is shown in Figure C-6 (Figure C-11 for Europe) – MDF and Cable Vault Schematic. Space-saver type MDF connectors will be used, unless otherwise directed by the U.S. Government.

3.12.3 MDF Cross-Connects

The MDF cross-connects are installed between the OSP terminations on the vertical connectors and the switch terminations on the horizontal blocks. This process connects an OSP pair to a telephone number. Approximately 200 mm (8 in) of slack will be left in the cross-connect wire to allow re-termination for moves, additions, or changes.

3.12.4 Special Circuits

Since special circuits, such as data circuits, T-1s, or alarms are non-switched, they will be treated differently than voice and modem circuits. The protector modules will be marked IAW the existing site procedure to indicate a special circuit. Various colors of protector modules are available to help in this differentiation. The special circuits will be cross-connected to designated blocks on the horizontal side (not to the switch blocks).

3.13 Building Terminations

3.13.1 Protected Entrance Terminals (PET)

3.13.1.1 Terminals and Hardware

Terminals and hardware will be UL-listed, and will be made of a flame-retardant construction and equipped with a built-in splice chamber; 5-pin gas protector modules, locking cover, and output on 66 block, 110 block, or RJ21 connectors.

3.13.1.2 Grounding

Refer to the USAISEC-FDED, *Grounding and Bonding Guidance*, January 2004.

3.13.2 Fiber Patch Panels

3.13.2.1 Fiber Termination Device

All strands of FOCs, both OSP and inside plant, will be properly terminated on fiber optic patch panels (FOPP). The OSP plant FOC will be extended IAW the NEC standards into the main data closet/location of the building and terminated there. If the main data closet/location cannot be determined, the OSP FOC will be terminated on a lockable patch panel collocated with the copper PET. Inside plant fiber optic riser cables between the main data closet/location and any satellite data closet(s)/location(s) will be terminated at both locations on the FOPPs. All FOPPs will be stenciled with the panel number and the cable count.

3.13.2.2 Fiber Terminations

All terminations will be made using subscriber connector (SC) or smart terminal (ST) connectors.

3.14 Free Space Optics

The Free Space Optics (FSO) can provide an alternative to fiber optic connectivity, for the "last mile," to EUBs and small enclaves. Typical FSO implementations arise from one of the following factors that prohibit traditional infrastructure– rapid deployment, right of way permit issues, water, railroads, and rough terrain. The FSO is a line-of-sight, point-to-point, wireless optic technology that uses the transmission of modulated IR beams through the atmosphere to obtain broadband communications. The FSO operates in the unlicensed near-IR spectrum 750- to 1550-nm wavelength range. The FSO systems can function over distances of several kilometers, as long as there is a clear line of sight between the source and the destination.

Design Note: For systems operating at 1.25 gigabits per second (Gbps), the link distance should be kept around 1000 m. If the FSO system operates in an environment of low visibility (fog), a back-up system (e.g., millimeter wave wireless (MMW), single-line high-bit-rate digital subscriber line (SHDSL), 802.11a) should be used.

There are a number of manufacturers producing the FSO equipment. The designer should utilize an FSO device that has been tested, approved, and recommended by the USAISEC-TIC. The FSO equipment will be designed to prevent data loss due to temporary blockages, such as birds, smoke, dust, rain, and light fog. The FSO devices must be Food and Drug Administration (FDA) and International Electrotechnical Commission (IEC) 60825-1 Class 1M approved to ensure safety. Operational test reports on individual equipment are available from USAISEC-TIC, such as AMSEL-IE-TI 04-009, *Free Space Optics (FSO) Comparison Report*, November 2003 and AMSEL-IE-TI 05-066, *Grafenwoehr Free Space Optics (FSO) Demonstration Report*, June 2005.

3.14.1 FSO Technical Requirements

The FSO will meet or exceed the following requirements:

a. Comply to or exceed industry standard emissions and eye safe considerations (e.g., certified eye safe as per IEC 60825 Class 1 or Class 1M).

b. Support Simple Network Management Protocol (SNMP) management.

c. Support remote configuration and management.

d. Remote diagnostics capabilities.

e. Environmental controls (heater, defrosters, etc.).

f. Automated acquisition of link capabilities.

g. Management channel.

h. Support for Gigabit Ethernet (GbE).

i. The equipment will be constructed so that it will have sufficient protection against dust, sand, or birds. Hardened housing will be used to provide a robust, waterproof environment.

The System will maintain its guaranteed performance when operated continuously or intermittently under any combination of the following conditions without readjustment and when maintained IAW the vendor's recommendation:

a. Ambient temperature: 10º C to 40º C (indoor) 10º C to 50º C (outdoor)

b. Relative humidity of up to 95 percent.

c. The system will be fully protected against lightning and voltage surge. It will also be protected against damages from accidental polarity reversal.

d. All test equipment, tools, accessories, and software necessary for the Operation and Maintenance support will be submitted as part of the FSO system offer.

3.14.2 FSO Consideration

The designer must consider a number of different factors when deploying FSO, including installation stability, beam alignment, mounting locations, atmospheric effects, impairments, required throughput, signal interfaces, security requirements, power requirements, and power availability.

3.14.2.1 Installation Stability and Beam Alignment

The FSO equipment is typically mounted on the outside edge of building rooftops, on towers, or inside building windows. These "solid" objects tilt, twist, vibrate, and sway due to, heat, wind load, and seasonal changes. The FSO equipment used should be able to compensate for minor movements and maintain beam alignment. There are generally two methods for keeping FSO laser transmitters and photo detection receivers aligned: active beam tracking and beam divergence. Active beam tracking allows the FSO system to adjust end-to-end alignment a small number of degrees through beam strength tracking. Beam divergence is the intentional spreading of the laser beam to allow for FSO link head movement within both receivers' field of view.

3.14.2.2 Mounting Locations, Atmospheric Effects, and Impairments

The FSO transmitters and receivers should be mounted as close to the building edge as possible. Setting the transmitters or receivers back could cause beam interference due to heat scintillation or refraction from the building roof. When placed within a building, the FSO can work through building windows with little or no attenuation. This allows the designer to avoid roof rights or premise cabling pathway issues. The designer should consider actual glass losses in the overall link budget for through window implementations. Additionally, the designer should investigate to see if newer windows are manufactured with an infrared (IR) reflecting coating or if older windows have a high lead content. The IR coating or lead could add severe impairment to an FSO link.

The designer must consider the occurrence of rain, dust, snow, fog, or smog when implementing the FSO. These weather conditions can add impairments to the transmission path. The USAISEC-TIC testing has shown fog to cause severe and sometimes total signal loss. Signal penetration through prevailing weather conditions is a factor of beam strength, distance, and weather interference. The FSO device should have gain control to accommodate distances and weather conditions. The gain control may be manual or automatic. However, beam power output is restricted by the eye safety requirements for this class of laser. The designer should consider a radio backup link for severe weather conditions, such as most MMW, microwave, and 802.11 wireless local area network (WLAN) or 802.16 Worldwide Interoperability for Microwave Access (WiMAX). The FSO laser does not need municipal or host nation approval, but the backup radio link may require approval and frequency management. The backup wireless link may have additional security requirements, as the RF signal or the FSO beam cannot be controlled.

3.14.2.3 FSO Security

Department of Defense Directive (DODD) 8100.bb requires Federal Information Processing Standard (FIPS) 140.2 Level 1 or 2, end-to-end encryption on all Army wireless implementations. Therefore, the designer must incorporate required encryption of data passed through the FSO required to pass FIPS 140-2 and Information Assurance (IA) certification. The designer should ensure that any encryption hardware is capable of supporting the throughout speeds and protocols.

3.14.2.4 FSO Throughput

The FSO throughput is a factor of beam strength, distance between devices, and weather conditions. The designer must consider the required bandwidth against the specific distance for each application. For systems operating at 1.25 Gbps, the link distance should be kept around 1000 m.

3.14.2.5 FSO Signal Interfaces

The FSO device should be able to interface to the local data switch through standard fiber optic connectors, such as SC-type connectors. The FSO device should be able to transparently transport the data stream.

3.15 General Range Information Infrastructure Design

The telecommunications sections of range construction projects must follow the general provisions of the U.S. Army Installation Information Infrastructure Architecture (I3A) technical guide for new construction and renovations. There are several distinct types of information networks in a range environment: Administrative, Range Control (RC), and Tactical. The Administrative networks support telephone and data requirements to the occupants of the range buildings, and safety telephones. The special RC networks control down-range targets, sensors, and monitors and transports this information to off-site locations. The Tactical networks support the unit training requirements in a field environment. In addition, there could be Security and Alarm networks.

These paragraphs provide guidance for the design of the administrative use networks with provisions for interfacing with the other networks. The following paragraphs provided specific design information for telecommunications rooms (TR) and OSP telecommunication cables for range projects.

3.15.1 Telecommunications Rooms (TR)

In multi-story buildings, a minimum of one TR must be located on each floor, with one TR acting as the aggregating TR or main cross-connect (MC) for the building. Small facilities (i.e., air traffic control towers, firing range towers, etc.) may use one TR for the entire facility. The TRs on successive floors must be vertically stacked, wherever possible. A minimum of four 4-in trade size conduits must be installed between stacked closets on successive floors, IAW ANSI/Electronic Industries Alliance/Telecommunication Industries Association (EIA/TIA)-569-B, Paragraph 8.12.

3.15.2 Backbone Cabling

The backbone cabling for range facilities must be single mode fiber optic IAW the I3A guide. The information technology (IT) designer must also refer to the I3A guide for supporting infrastructure for the distribution and riser cables.

3.16 Range Information Infrastructure Design

Utilizing the RC building as a distribution node for all range telecommunications and as an intermediary between the ranges and the main cantonment area provides the ideal range information infrastructure architecture. The DB cable plant must be used for range telecommunications cables. If it is not feasible to use DB cable due to local mandates or rough terrain, aerial cable plant may be used. Pedestals or maintenance holes must be placed at end of reel splice locations, where access to cable pairs or strands is required, and at future use points. In some range scenarios, a maintenance hole or a buried splice would be preferred over a pedestal due to the free roaming abilities of heavy equipment, such as tanks and mowers. When using pedestals, efforts must be taken to protect it from damage, such as protective stub poles, locations in tree lines, or close-to-steep banks. When using buried splices, above ground warning signs and electronic locating devices, such as radio frequency ID or magnetic devices, must be located with the splice.

3.16.1 Maintenance Hole and Duct Systems

The IT designer must normally not use the maintenance hole and duct systems architecture in the range environment. Maintenance holes and ducts would incur too high a cost to the range project. At individual range complexes, a maintenance hole and duct infrastructure could be installed from RC building to adjacent support buildings for growth and expansion. When a duct system is required, a minimum of two 4-in PVC ducts, one with four sub-ducts or nine-way (3 each 3-way) textile mesh, must be installed to each individual support building.

3.16.2 Direct Bury Depth of Placement

The minimum depth of placement for a DB copper cable to ranges must provide cover of 36 in of soil; 48 in at ditch crossings, and 6 in of solid rock. To direct bury a FOC, the minimum depth must provide a cover of 42-in overall. In solid rock, the minimum depth is reduced to 6 in for FOC. The DOIM may have special depth requirements for certain areas, such as tank trails, firing ranges, etc.

3.16.3 Concrete Encasement

The IT designer must normally not use a concrete-encased underground maintenance hole or duct systems in the range environment. Maintenance holes and ducts would incur too high a cost to the range project. Concrete encasement or GSP must be used in range projects under road crossings, heavy equipment (tank) crossing, or high traffic areas. The IT designer must plan for four 4-in PVC ducts; one with four sub-ducts or nine way (3 each 3-way) textile innerducts, under road crossings, heavy equipment (tank) crossings, and high traffic areas. The encasement/pipe must be extended a minimum of 6 ft beyond the roadbed for all road crossings, heavy equipment (tank) crossings, and high traffic areas on ranges. In accordance with the referenced standards, PVC ducts must also be encased in concrete at all sweeps or bends; at stream or drainage ditch crossings, or other areas subject to washout. For consistency, the contractor must use only one brand of cement that conforms to RUS Bulletin 1751F-644 (http://www.usda.gov/rus/telecom/publications/pdf_files/1751f644-08-02.pdf).

3.16.4 OSP Cable

The IT designer must consider DB cables as the first choice for range telecommunications cables. If it is not feasible to use DB cables due to local mandates or rough terrain, aerial cables shall be used. The IT designer must specify a minimum of 24 strands of single mode FOC from the DCO, or closest RSU, to RC building. Alternatives to FOC between the main cantonment area and the RC building may be considered on a case-by-case basis. The IT designer must also specify a minimum of 12 strands of single mode FOC from the RC building to the individual ranges or range buildings. The IT designer must use single mode FOC, as needed, to extend the data backbone, monitor circuits, sensors, cameras etc., to all range buildings from the RC building. In addition to the normal administratively required strands of FOCs for voice and data networks to the ranges, the range cables must be sized to support circuits for the ever-changing training and tactical scenarios, and RC (minimum 25-percent spare strands). Cables homed to the RC facility would add flexibility to these systems.

3.17 Multiplexing Equipment

The contractor will engineer, furnish, install, and test (EFI&T) electronic components as cited in the site-specific SOR/EDP. All electronic designs will take site preferences into consideration, and the equipment will be fully integrated into the existing network. The contractor will adhere to the following when specifying electronic equipment.

3.17.1 Protection Circuits

Protection circuits will be provided in a ratio of 1:N as additional multiplexing equipment of the same type. Equipment racks will be wired to provide the resulting protection ratio and will provide for automatic or manual switching.

3.17.2 Fiber Optic Digital Multiplex Equipment

The fiber multiplexer, demultiplexers (MULDEM) will operate at the digital signal (DS) Level 2 (DS-2), DS-3, or DS-3C rate. DS-2 will mean 4 DS-1 channels, DS-3 will mean 28 DS-1 channels, and DS-3C will mean 56 DS-1 channels. Fiber optic MULDEMs will be able to accept electrical interface cards that operate at DS-1, DS-1C, or DS-2 rates in any combination. DS-3C fiber optic MULDEMs will also be able to accept input at the DS-3 rate in addition to the other rates. The option for protection circuits will be provided with a ratio of up to 1:1 for the high-speed side.

3.17.3 Synchronous Optical Network

A SONET fiber optic MULDEM will be configured for optical carrier (OC)-3, OC-12, and OC-48 rates. The basic shelf for both multiplexers will provide software for operation in terminal-to-terminal and add/drop configurations. Ring configuration software for both multiplexers will be provided. The multiplexers will comply with the ANSI T1.105a and the Bellcore Standards on SONET; they will not use any reserved or unused bytes in the SONET format for proprietary end-to-end signaling; and they will provide multiplexing/demultiplexing for transmission over a single or multimode fiber optic link. Each system will be capable of operating on a 48-VDC power supply. The OC-3, OC-12, and OC-48 shelves will be equipped with protective fuses or circuit breakers. In the DCO applications, the power and system alarm cables will be installed from the equipment shelf to the existing power distribution panel or power cable gutter tap point. When required, connections to the existing power panel/cable will be performed. The system will provide 1:1 ratio of protection for all common control circuitry packs. The system will provide 1:N ratio of protection of low-speed interface circuit packs. The low-speed circuit pack protection will be provided by adding circuit packs, as required, for individual sites. Two shelf-mounted cooling fans will be included when recommended by the manufacturer or if conditions dictate convection cooling.

3.17.3.1 OC-3 SONET Multiplexer

The OC-3 SONET multiplexers will operate at 155.52 megabits per second (Mbps) and support DS-, DS-3, and EC-1 low-speed interfaces. Low-speed input choices will range from 1 to 84 DS-1s, 3 DS-3s, or 3 EC-1s, with a mixture of each possible. The system will support terminal-to-terminal operation and sophisticated hubbing, add/drop, and ring topologies.

3.17.3.2 OC-12 SONET Multiplexer

The OC-12 SONET multiplexers will operate at 622.08 Mbps and supports DS-3, (or EC-1), and OC-3 low-speed interfaces. The system will support terminal-to-terminal operation, hubbing, add/drop, and ring topologies. The system will be upgradeable to support synchronous transport signal (STS)-3C, asynchronous transfer mode (ATM), fiber optic digital data interface (FDDI), and broadband-integrated services digital network (B-ISDN) with new software or through replacement and/or reprogramming of port circuit packs.

3.17.3.3 OC-48 SONET Multiplexer

The OC-48 SONET multiplexers will operate at 2.488 Gbps and support DS-3, (or STS-1E), OC-3, and OC-12 low-speed interfaces. The system will support terminal-to-terminal operation, hubbing, add/drop, and ring topologies and will be upgradeable to support STS-3C, ATM, FDDI, and B-ISDN with new software or through replacement and/or reprogramming of port-circuit packs.

3.17.4 Fiber Optic Subscriber-loop Equipment

Subscriber-loop multiplexers will operate at the DS-1 (24 subscriber loops) or DS-2 (96 subscriber loops) rate. They will include both the central office terminal (COT) and the remote terminal (RT). The subscriber-loop multiplexers will provide battery feed, over-voltage protection, ringing, signaling, coding, hybrid, and testing (BORSCHT) for each subscriber loop.

3.17.5 Channel Banks/Systems

The contractor will furnish and install channel banks that are end-to-end compatible with D-1D, D-2, D-3, and D-4 channel-bank equipment. Line interface units will operate at a minimum of Mode 3.

3.17.6 Transmitters and Receivers

The transmitters will be compatible with channel banks, multiplexers, and other electronic equipment.

3.17.6.1 Transmitters

a. Multimode Systems: In a multimode system, the transmitter may be a light emitting diode (LED) or an injection laser diode (ILD). The LEDs and ILDs may be 780 nm +/-25 nm, 850 nm +/-25 nm, or 1300 nm +/-25 nm. The ILD will feature a thermo-electric cooler for longer, dependable laser operation.

b. Single-mode Systems: In a single-mode system, the transmitter will be an ILD, which will operate at 1310 nm +/-25 nm and feature a thermo-electric cooler for longer, dependable laser operation. The ILD may be a high-output type or a standard-output type, as required by the power budget/loss calculations for the circuit.

3.17.6.2 Receivers

a. Multimode Systems: In a multimode system, the receiver will be either an avalanche photo diode (APD) or a positive intrinsic negative (PIN) diode.

b. Single-mode Systems: In a single-mode system, the receiver will be either an APD or a PIN diode.

3.17.7 Emergency Backup Power Systems

Power systems will be provided with a backup battery source with a minimum eight-hour capacity for remotely located shelters or shelters not equipped with an emergency generator. Otherwise, they will be sized to provide a minimum of four hours of operation. Recharging equipment will be supplied with batteries that will provide a complete recharge from low-voltage cutoff in 24 hours or less.

3.18 Environmentally-Controlled Housing

The contractor will provide environmentally-controlled housing, as cited in the site-specific SOR/EDP. The environmentally controlled huts/vaults will be constructed and placed IAW the NFPA NEC and American Society of Heating, Refrigeration and Air Conditioning criteria. The hut will include a high efficiency, computer-controlled air conditioning system capable of maintaining the required temperature and humidity levels of 23 (+/-3)^{o} C (74 [+/-5]^{o} Fahrenheit [F]), dry bulb, and 10^{o} C (50 [+/-5]^{o} F), 10 percent, respectively. The system will monitor the environmental conditions and provide alarms whenever the levels fall out of the acceptable range, and it will switch automatically to the standby unit in the event of a primary unit failure. Enclosures/vaults will be constructed to adequately support all requirements of equipment and environmental control devices. The U.S. Government will provide commercial power to the power distribution board in the huts/vaults so that the contractor can make all components of the hut/vault operational.

3.18.1 Features

The following features, unless otherwise modified by the site-specific SOR/EDP, will be included as standard in all environmentally controlled housings:

- Overhead lighting
- Wall receptacles, 110 volts alternating current (VAC); 220 VAC in Europe; minimum of one receptacle every 3 m (10 ft) required
- Built-in ladder (underground vaults)
- Alarm system (alerts central office)
- Fire extinguisher (wall-mounted carbon dioxide [CO2])
- R-21 insulation
- Bullet and vandal resistance
- Fire retardant
- Corrosion resistance
- 100-ampere (amp) power panel (small huts and vaults)
- 200-amp power panel (midsize and large size huts and vaults)

3.18.2 Equipment Enclosures

Equipment enclosures will be available in three sizes; the inside dimensions are length x width x height:

- 3 m x 3 m x 3 m (10 ft x 10 ft x 10 ft) with 50 amp @ 220-VAC (100 amp @ 110-VAC) power panel
- 4.9 m x 3 m x 3 m (16 ft x 10 ft x 10 ft) with 100 amp @ 220-VAC (200 amp @ 110-VAC) power panel
- 6.4 m x 3.6 m x 3 m (21 ft x 12 ft x 10 ft) with 100 amp @ 220-VAC (200 amp @ 110-VAC) power panel

Note: The length and width dimensions will be those noted as a minimum but may increase provided that the square footage meets or exceeds the sizes listed. The height dimension may vary by +/-300 mm (1 ft).

3.18.3 Environmentally-Controlled Vault

Environmentally-controlled vaults will be placed underground only with environmental control units and access above the ground. They will be available in two sizes; the inside dimensions are length x width x height:

- 3 m x 3 m x 2.7 m (10 ft x 10 ft x 9 ft) with 50 amp @ 220-VAC (100 amp @ 110-VAC) power panel
- 4.9 m x 3 m x 3 m (16 ft x 10 ft x 10 ft) with 100 amp @ 220-VAC (200 amp @ 110-VAC) power panel

Note: The length and width dimensions will be those noted as a minimum but may increase provided the square footage meets or exceeds the sizes listed. The height dimension may vary by +/-300 mm (1 ft).

3.18.4 Alarm System (Huts)

The huts will be minimally equipped with the following alarm systems that will provide an alarm condition and a remote connection to a dry contact:

- Low temperature
- High temperature
- High humidity
- Intrusion
- Power off

3.18.5 Alarm System (Vaults)

The vaults will be minimally equipped with the following alarm systems that will provide an alarm condition and a remote connection to a dry contact:

- High water
- High temperature
- High humidity
- Vent
- Toxic gas

- Explosive gas
- Intrusion
- Power off
- Smoke

3.18.6 Equipment Racks and Associated Ironwork

Equipment racks will be sized to accommodate any electronics cited in the site-specific SOR/EDP. Racks will be provided that are capable of being integrated into any existing rack/cabinet system. Guardrails will be included on each equipment rack, and the copper grounding bar will be installed and grounded to the master ground bar (MGB). The equipment racks will be insulated from the anti-static floor tile, as well as from the overhead cable racks and other ironwork. All cable racks will be bonded across splices with insulated 45-Metric Wire Gauge (MWG) (6-AWG) wire. The bonded cable rack/tray system will be grounded to the MGB and isolated from all relay/equipment racks, distributing frames and other equipment.

3.18.7 Bulk Power

The power system for all electronics designed for installation in the DCO/RSUs, where battery systems are available, will be derived from a 48-VDC uninterruptible power supply (UPS) consisting of battery chargers (rectifiers), sealed maintenance-free batteries, and direct current (DC) power boards.

3.18.7.1 Rectifiers

All rectifier operational alternating current (AC) voltages will comply with the AC-input voltage range specified as 120/208 VAC 3-phase, 60 Hz (220 VAC 50, Hz in Europe). The system will provide rectifiers of sufficient output to power the equipment load while providing recharging on a discharged battery string to 95 percent of its charged condition within 24 hours. A standby rectifier will also be provided. Upon restoration of commercial power, or the activation of an AC-standby power system, the rectifiers will automatically return on-line and begin recharging the battery plant while providing DC power.

3.18.7.2 Batteries

Batteries will be the sealed recombining cells or maintenance-free type batteries. They will have a life expectancy of 20 years when properly maintained on a full-float operation within the range of 2.23 to 2.27 volts per cell (VPC) under a continuous ambient temperature of 25^{o} C (77^{o} F). A battery plant will provide an 8-hour source of backup DC power for system operation when the AC power is down.

3.18.7.3 Power Distribution Board

a. The power distribution board will be equipped with circuit breaker/fuse panels, ground bar, termination panels, alarm panel, meter panel, and associated hardware.

b. The power distribution board will have a common point where batteries and rectifiers are connected together to provide the associated equipment power frames with access to the DC power plant. The board will also have a ground (positive) bus that is grounded to the equipment system.

c. Negative feeds from the power distribution board to the associated equipment power frames will be protected through fuses and/or circuit breakers. Feeders will be sized to accommodate the peak current for a circuit under worst-case conditions.

d. The maximum voltage drop between battery and power-board output will not exceed 0.25 v.

3.19 Digital Cross-Connect

A cross-connect is a centralized termination point that provides connections that can be rearranged between any two equipment terminations or appearances. The cross-connect location determines operational functions, such as equipment interconnection, test access, and patching.

3.19.1 Automated Cross-Connect Function

a. The digital cross-connect system will provide the ability to connect, move, and disconnect circuit assignments without rewiring interconnect devices.

b. The system will be a flexible and functional open-system architecture. The digital cross-connect will be capable of interfacing and cross-connecting DS-1 and will be upgradeable to DS-3 and SONET.

c. The system will be capable of, but not limited to, handling plain old telephone service (POTS) lines, Centrex Central Office (CO) lines, direct out dial (DOD) lines, local private branch exchange (PBX) trunks, off-premise extensions, 800 service lines, wide area telephone service (WATS) lines, and DSN lines.

d. The system will be capable of changing the time slot assignment of individual DS-1 streams (time slot interchanges).

e. The system will not require digital to analog (D/A) conversion or subsequent analog to digital (A/D) conversion. The cross-connections will be accomplished entirely at the DS-0 channels for monitoring and test purposes.

f. The system will have minimum delay to frames and no greater than 500 microseconds (µs) into the transmission.

g. The system will have a network management function to provide for administration, assignment, and configuration changes. The system will be updated at the host and remotely.

h. The system will be capable of testing telephone lines in both directions and identifying problems. The digital cross-connect system being proposed will have, but will not be limited to, the following capabilities:

- Add circuit assignments
- Delete circuit assignments
- Move circuit assignments, both on the network side and subscriber side
- Update line records
- Store and update cable record information
- Change various line-card configurations
- Self-diagnostic system alarms

- Switch to redundant equipment
- Perform database backup and recovery
- Security, add and delete user access
- UPS

3.19.2 Test Access

For testing purposes, the digital cross-connect equipment will allow individual DS-0 channels within a 24-channel DS-1 bit stream. The access channel will be capable of being monitored and/or tested on a bridged or a split and terminated basis. The system will provide performance and alarm monitoring. Each DS-1 signal interfaced to the DCS will be capable of being monitored for proper performance including framing losses, frame slips, and bit error rate. Carrier group alarms will be generated, when required, as for normal carrier operation. External alarms will be provided for power failures and carrier failures.

4.0 QUALITY ASSURANCE

4.1 General

Any and all work performed in deviation to the specification, the project drawings, or the standards will immediately be corrected by the contractor, regardless of the stage of completion. The U.S. Government reserves the right to witness and verify all inspections and testing specified herein. Acceptance is contingent upon satisfactory demonstration that all of the requirements have been met.

4.2 Quality Assurance Inspections and Testing

4.2.1 Spot Inspections

The U.S. Government will perform spot inspections and conduct random, periodic inspections during the installation process to ensure that the contractor is adhering to the referenced standards and practices.

4.2.2 Final Inspection

Prior to final acceptance the contractor will conduct a final inspection conducted jointly with the U.S. Government QA representative. During the joint final inspection of all installed plants, the contractor will verify the redline drawings and demonstrate compliance to the EDP to the U.S. Government QA representative of all OSPs and inside plants. As part of the joint final inspection, the contractor will open, pump, and demonstrate to the U.S. Government QA all completed maintenance holes and verify the accuracy of the redline drawing package. Where installation discrepancies are found during the joint final inspection, the contractor will correct the discrepancies and demonstrate the corrected item to the U.S. Government QA representative. The contractor will schedule the joint final inspection and provide the U.S. Government QA representative at least three-weeks notice prior to the event.

Additionally, the U.S. Government will participate in and witness the final acceptance testing. Project integrity will be assured through installation inspections, final joint inspections, and acceptance testing, as well as proper material handling to prevent damage.

4.3 Quality Assurance References

Testing will be done IAW RUS Bulletin 1753F-201, RUS TE&CM Standard PC-4, RS-455, RS-422, RS-423, ANSI/American Society for Quality Control (ASQC) Q94-1987, ANSI EIA/TIA 492, and ANSI EIA/TIA 568-B (Annex H) and applicable equipment manuals.

4.4 Final Acceptance Test

4.4.1 Telecommunications Cable Plant

Testing will consist of, but will not be limited to, the following cable tests:

- Insulation resistance
- Shorts/crosses
- Grounds
- Opens
- Reversals
- Splits
- Transpositions
- Shield continuity
- Loop resistance
- Insertion loss (performed only when specified)
- Capacitance

4.4.2 Fiber Optic Cable

Testing will consist of Optical Time Domain Reflectometer (OTDR) measurements for one strand in each 12-strand bundle of fiber, and Power Source/Power Meter tests on every strand in all cables. Each strand of fiber cable not terminated at each end will be tested with the OTDR. While using the OTDR, measure the length of the strand and look for any circuit discontinuities and/or splice points. Run a strip chart for each fiber strand tested and record the cable ID, strand ID, source location, meter location, and dB loss at each specified nm wavelength and fiber length, and note whether the strand passed or failed the test. The following tests will also be included as a minimum:

- Attenuation
- Bandwidth
- Power Source/Power Meter: This test will consist of bi-directional, dual-window (1,300/1,550 nm) testing of every fiber strand installed.

4.4.3 Electronic End Equipment

The following tests will be run as a minimum:

- Functionality
- Built-in diagnostic tests

Table 6 shows the standard cable reel lengths and diameters.

Table 6. Standard Cable Reel Lengths and Diameters

Cable Type	Number of Pairs	AWG	Standard Length (ft)	Nominal Diameter (in)
PE-22	6 x	19	5,000	0.53
Air Core	12 x	19	5,000	0.6
Alpeth	25	19	5,000	0.81
Sheath	50	19	2,500	1.08
	6 x	22	5,000	0.43
	12 x	22	5,000	0.53
	25	22	5,000	0.7
	50	22	5,000	0.85
	100	22	5,000	1.07
	200	22	5,000	1.48
	300	22	2,000	1.75
	400	22	2,000	1.96
	600	22	1,000	2.44
	900	22	1,000	2.88
	1,200	22	750	3.29
	6 x	24	10,000	0.41
	12 x	24	10,000	0.46
	25	24	10,000	0.55
	50	24	5,000	0.66
	100	24	5,000	0.87
	200	24	5,000	1.18
	300	24	2,500	1.38
	400	24	2,500	1.53
	600	24	2,500	1.85
	900	24	1,500	2.31
	1,200	24	1,000	2.69
	1,500	24	1,000	2.92
	1,800	24	750	3.01
	2,100	24	500	3.39
	25	26	10,000	0.49
	50	26	10,000	0.57
	100	26	10,000	0.71
	200	26	5,000	0.97
	300	26	5,000	1.14
	400	26	5,000	1.30
	600	26	2,500	1.54
	900	26	2,500	1.88
	1,200	26	1,500	2.10
	1,500	26	1,500	2.32
	1,800	26	1,000	2.48
	2,100	26	1,000	2.68
	2,400	26	1,000	2.90
	2,700	26	1,000	3.03
	3,000	26	750	3.20
Figure-8	6 x	22	9,930	0.96
Filled	12 x	22	9,930	1
Alpeth	25	22	9,810	1.16
Sheath	50	22	6,540	1.34
	6 x	24	11,340	0.88
	12 x	24	11,340	0.96
	25	24	11,340	1.02

Table 6. Standard Cable Reel Lengths and Diameters (continued)

Cable Type	Number of Pairs	AWG	Standard Length (ft)	Nominal Diameter (in)
	50	24	11,340	1.18
	50	26	13,320	1.08
	100	26	8,820	1.26
PE-89	6 x	19	5,000	0.52
Filled	12 x	19	5,000	0.62
Alpeth	25	19	5,000	0.86
Sheath	50	19	5,000	1.12
	100	19	2,500	1.51
	200	19	1,500	2.04
	6 x	22	5,000	0.48
	12 x	22	5,000	0.52
	25	22	5,000	0.66
	50	22	5,000	0.86
	75	22	5,000	0.96
	100	22	5,000	1.1
	150	22	5,000	1.32
	200	22	2,500	1.49
	300	22	2,000	1.72
	400	22	2,000	1.96
	600	22	1,000	2.4
	900	22	1,000	2.9
	1,200	22	750	3.28
	6 x	24	10,000	0.44
	12 x	24	10,000	0.48
	25	24	10,000	0.58
	50	24	10,000	0.7
	75	24	5,000	0.86
	100	24	5,000	0.94
	150	24	5,000	1.06
	200	24	5,000	1.2
	300	24	2,500	1.45
	400	24	2,000	1.59
	600	24	2,000	1.92
	900	24	1,000	2.32
	1,200	24	1,000	2.68
	1,500	24	1,000	2.92
	1,800	24	750	3.2
	2,100	24	600	3.44
	25	26	10,000	0.52
	50	26	10,000	0.58
	100	26	10,000	0.78
	200	26	5,000	1.02
	300	26	5,000	1.18
	400	26	5,000	1.33
	600	26	2,500	1.59
	900	26	2,000	1.92
	1,200	26	1,500	2.1
	1,500	26	1,000	2.34
	1,800	26	1,000	2.6
	2,100	26	1,000	2.78
	2,400	26	1,000	2.92

Table 6. Standard Cable Reel Lengths and Diameters (continued)

Cable Type	Number of Pairs	AWG	Standard Length (ft)	Nominal Diameter (in)
	2,700	26	750	3.14
	3,000	26	750	3.24
	6 x	19	5,000	0.58
PE-89	12 x	19	5,000	0.66
Filled	25	19	5,000	0.9
Rodent	50	19	2,500	1.18
Protected	6 x	22	5,000	0.54
Alpeth	12 x	22	5,000	0.58
Sheath	25	22	5,000	0.7
	50	22	5,000	0.9
	100	22	5,000	1.14
	200	22	2,500	1.51
	300	22	2,000	1.76
	400	22	2,000	2
	600	22	1,000	2.46
	900	22	1,000	2.94
	1,200	22	750	3.28
	6 x	24	10,000	0.5
	12 x	24	10,000	0.54
	25	24	10,000	0.58
	50	24	10,000	0.74
	100	24	5,000	0.98
	200	24	5,000	1.26
	300	24	2,500	1.49
	400	24	2,000	1.63
	600	24	2,000	1.96
	900	24	1,000	2.36
	1,200	24	1,000	2.68
	1,500	24	1,000	2.94
	1,800	24	750	3.22
	25	26	10,000	0.58
	50	26	10,000	0.66
	100	26	10,000	0.82
	200	26	5,000	1.08
	300	26	5,000	1.22
	400	26	5,000	1.38
	600	26	2,500	1.63
	900	26	2,000	1.92
	1,200	26	1,500	2.11
	1,500	26	1,000	2.36
	1,800	26	1,000	2.62
	2,100	26	1,000	2.78
	2,400	26	1,000	2.94
	2,700	26	750	3.18
	3,000	26	750	3.26

Table 7 shows the European Standard cable reel lengths and diameters.

Table 7. European Standard Cable Reel Lengths and Diameters

Cable Type	Number of Pairs	Conductor Size (mm)	Standard Reel Length (m)	Nominal Outside Diameter mm (in)
A-2YF(L)2Y	2	0.6	Special order only	9.0 (0.35)
PE insulation	4	0.6	Special order only	11.5 (0.45)
Jelly filled cable core	6	0.6	1,000	12.0 (0.47)
Laminated sheath	10	0.6	1,000	13.5 (0.53)
DIN VDE 0816	20	0.6	1,000	16.5 (0.65)
	30	0.6	1,000	19.5 (0.77)
	50	0.6	1,000	23.5 (0.93)
	100	0.6	1,000	31.5 (1.24)
	150	0.6	1,000	37.5 (1.48)
	200	0.6	1,000	42.5 (1.67)
	300	0.6	500	52.0 (2.05)
	500	0.6	300	67.0 (2.64)
	600	0.6	300	74.0 (2.91)
	800	0.6	300	85.0 (3.35)
A-2YF(L)2Y	6	0.8	1,000	13.0 (0.51)
PE insulation	10	0.8	1,000	15.0 (0.59)
Jelly filled cable core	20	0.8	1,000	18.0 (0.71)
Laminated sheath	30	0.8	1,000	21.0 (0.83)
DIN VDE 0816	50	0.8	1,000	26.0 (1.02)
	100	0.8	1,000	34.0 (1.34)
	150	0.8	500	40.0 (1.57)
	200	0.8	500	47.0 (1.85)
	300	0.8	300	61.0 (2.40)
	500	0.8	300	78.0 (3.07)

Table 8 shows a sample of a cable spreadsheet.

Table 8. Cable Spreadsheet Sample

Termination	Required Copper Pairs	Served From	Copper Cable & Count	Required Fiber Strands	Served From	Fiber Cable & Count	Priority	Remarks
MH 5	900	B 376	6, 1-900 C/C	N/A	N/A	N/A	Phase 1	
B 390	900	B 376	6, 901-1,800	192	B 376	FOC A, 1-192	Phase 1	Backbone fiber to ADN.
B 220	50	B 376	7, 1-50	12	B 376	FOC A-2, 25-36	Phase 2	
B 218	100	B 376	7, 51-150	12	B 376	FOC A-2, 37-48	Phase 2	
B 219	100	B 376	7, 151-250	12	B 376	FOC A-2, 49-60	Phase 2	
B 233	50	B 376	7, 251-300	12	B 376	FOC A-2, 61-72	Phase 2	
B 223	100	B 376	7, 301-400	12	B 376	FOC A-2, 73-84	Phase 2	
B 224	200	B 376	7, 401-600	12	B 376	FOC A-2, 85-96	Phase 2	
B 231	100	B 376	7, 601-700	12	B 376	FOC A-2, 97-108	Phase 2	
B 228	100	B 376	7, 701-800	12	B 376	FOC A-2, 109-120	Phase 2	
B 227	100	B 376	7, 801-900	12	B 376	FOC A-2, 121-132	Phase 2	
B 225	100	B 376	7, 901-1,000	12	B 376	FOC A-2, 133-144	Phase 2	
B 202	100	B 376	7, 1001-1,100	12	B 376	FOC A-1, 1-12	Phase 2	
B 203	100	B 376	7, 1101-1,200	12	B 376	FOC A-1, 13-24	Phase 2	
B 214	100	B 376	7, 1201-1,300	12	B 376	FOC A-1, 25-36	Phase 2	
B 204	100	B 376	7, 1501-1,600	12	B 376	FOC A-1, 37-48	Phase 2	
B 212	100	B 376	7, 1401-1,500	12	B 376	FOC A-1, 49-60	Phase 2	
B 206	100	B 376	7, 1301-1,400	12	B 376	FOC A-1, 61-72	Phase 2	
B 192	100	B 376	7, 1601-1,700	12	B 376	FOC A-1, 73-84	Phase 2	
B 193	100	B 376	7, 1701-1,800	12	B 376	FOC A-1, 85-96	Phase 2	
B 399				12	B 376	FOC D1, 1-12	Phase 2	LAN C-DCO is B 376.

C/C=center-to-center; LAN=local area network; MH=maintenance hole

APPENDIX A. EXCAVATION, TRENCHING, AND BACKFILLING

A-1.0 EXCAVATION, TRENCHING, AND BACKFILLING GENERAL

A-1.1 References

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

a. ASTM D 1556-90, *Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method*, June 1990.

b. ASTM D 1557-91, *Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 [2,700 kN-m/m3])*, 1991.

c. ASTM D 2167-94, *Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method,* March 1994.

d. ASTM D 2487-00, *Standard Test Method for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*, September 1993.

e. ASTM D 2922-91, *Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)*, December 1991.

f. ASTM D 3017-88, *Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)*, May 1988.

A-1.2 Excavation

A-1.2.1 Trench Excavation

Trench excavation will be the number of linear feet measured along the centerline of the trench and excavated to the depths and widths specified for the particular size and formation of pipe/conduit. No increase will be made for the extra width required at maintenance holes and similar structures. Trench excavation will include excavation and backfilling (including specified over depth), except in rock or unstable trench bottoms. Unstable trench bottoms will be replaced by select granular material and paid for as specified below. Trench excavation will also include the additional width at maintenance holes and similar structures, the furnishing, placing and removal of sheeting and bracing, pumping and bailing, and all incidentals necessary to complete the work required by this section.

A-1.2.2 Rock Excavation

Rock excavation will be measured by the number of cubic yards of acceptably excavated rock material. The material will be measured in place, but volume will be based on a maximum 760-mm (30-in) width for pipes 300 mm (12 in) in diameter or less, and a maximum width of 400 mm (16 in) greater than the outside diameter of the pipe for pipes over 300 mm (12 in) in diameter. The measurement will include all authorized over-depth rock excavation as determined by the U.S. Government representative. For maintenance holes and other appurtenances, volumes of rock excavation will be computed on the basis of 300 mm (1 ft) outside of the wall lines of the structures. Rock excavation will include all necessary drilling and blasting and all incidentals necessary to excavate and dispose of the rock. Backfill replacing will be included in the rock excavation.

A-1.3 Degree of Compaction

The degree of compaction will be expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557-91.

A-2.0 MATERIALS

A-2.1 Satisfactory Materials

Satisfactory materials will comprise any materials classified by ASTM D 2487-00 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, [SM,] [SW-SM,] [SC,] [SW-SC,] [SP-SM,] [SP-SC,] [CL,] [ML,] [CL-ML,] [CH,] [MH]. (See the reference for details of these classifications.)

A-2.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills, trash, refuse, or backfill from previous construction. Unsatisfactory materials also include material classified as satisfactory but which contains root and other organic matter, frozen material, and stones larger than four in. The U.S. Government representative will be notified of any contaminated materials.

A-2.3 Cohesionless and Cohesive Materials

Cohesionless materials will include materials classified in ASTM D 2487-00 as GW, GP, SW, and SP. Cohesive materials will include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are non-plastic. (See the reference for details of these classifications.)

A-2.4 Rock

Rock will consist of boulders measuring 0.382-cm^3 (1/2-yd^3) or more and materials that cannot be removed without systematic drilling and blasting, such as rock material in ledges, bedded deposits, unstratified masses and conglomerate deposits, and below-ground concrete or masonry structures, exceeding 0.382-cm^3 (1/2-yd^3) volume, except that pavements will not be considered as rock.

A-2.5 Unyielding Material

Unyielding material will consist of rock and gravelly soils with stones greater than four in in any dimension or as defined by the pipe manufacturer, whichever is smaller.

A-2.6 Unstable Material

Unstable material will consist of materials too wet to properly support the utility pipe, conduit, or appurtenant structure.

A-2.7 Select Granular Material (Select Backfill)

Select granular material will consist of well-graded sand, gravel, crushed gravel, crushed stone or crushed slag composed of hard, tough and durable particles. It will contain no more than 10 percent by weight of material passing a No. 200 mesh sieve and no less than 95 percent by weight passing the 25-mm (l-in) sieve. The maximum allowable aggregate size will be 40 mm (1-1/2 in), or the maximum size recommended by the pipe/conduit manufacturer, whichever is smaller.

A-2.8 Initial Backfill Material

Initial backfill will consist of select granular material or satisfactory materials free from rocks 50 mm (2 in) or larger in any dimension, or free from rocks of such size as recommended by the pipe/conduit manufacturer, whichever is smaller. When the pipe is coated or wrapped for corrosion protection, the initial backfill material will be free of stones larger than 1-in in any dimension or as recommended by the pipe/conduit manufacturer, whichever is smaller.

A-2.9 Plastic Warning Tape

Traceable plastic warning tape will be acid and alkali-resistant PE film, 150-mm (6-in) minimum width with a minimum thickness of 0.01 mm (0.004 in). The tape will have a minimum strength of 12,070-kPa (1,750-PSI) lengthwise and 10,300-kPa (1,500-PSI) crosswise. The tape will be manufactured with integral wires, foil backing, or other means to enable detection by a metal detector when the tape is buried up to 900-mm (3-ft) deep. The tape will be of a type specifically manufactured for marking and locating underground utilities. The metallic core of the tape will be encased in a protective jacket or provided with other means to protect it from corrosion. The warning tape color will be as specified in Table A-1 and will bear a continuous printed inscription describing the specific utility.

Table A-1. Warning Tape Color

Color	Description
Red	Electric
Yellow	Gas, Oil, Steam, Petroleum, and Dangerous Materials
Orange	Telephone, Telegraph, Television, Police, and Fire Communications
Blue	Water Systems
Green	Sewer and Drain Systems

A-3.0 EXECUTION

A-3.1 Excavation

Excavation will be performed to the lines and grades indicated. Rock excavation will include removal and disposition of materials defined as rock in Paragraph A-2.0 (Materials). Earth excavation will include removal and disposal of material not classified as rock excavation. During excavation, material satisfactory for backfilling will be stockpiled in an orderly manner at a distance from the banks of the trench equal to one-half the depth of the excavation, but no closer than 600 mm (2 ft). Excavated material not required or not satisfactory for backfill will be removed from the site or will be disposed of by hauling it to an approved dump area on the installation. Grading will be done as may be necessary to prevent surface water from flowing into the excavation, and any water accumulating will be removed to maintain the stability of the bottom and sides of the excavation. Unauthorized over-excavation will be backfilled IAW Paragraph A-3.3 (Backfilling and Compaction) at no additional cost to the U.S. Government.

A-3.1.1 Trench Excavation Requirements

The trench will be excavated as recommended by the manufacturer of the pipe/conduit to be installed. Trench walls below the top of the pipe/conduit will be sloped, or made vertical, and of such width as recommended in the manufacturer's installation manual. Where no manufacturer's installation manual is available, trench walls will be made vertical. Trench walls more than 1.5-m (5-ft) high will be shored, cut back to a stable slope, or provided with equivalent means of protection for employees who may be exposed to moving ground or cave-in. Vertical trench walls more than 1.5-m (5-ft) high will be shored. Trench walls, which are cut back, will be excavated to at least the angle of repose of the soil. Special attention will be given to slopes, which may be adversely affected by weather or moisture content. The trench width below the top of the pipe/conduit will not exceed 600 mm (24 in) plus the pipe's outside diameter for pipes of less than 600-mm (24-in) inside diameter and will not exceed 900 mm (36 in) plus the pipe's outside diameter for sizes larger than 600-mm (24-in) inside diameter. The contractor will use redesigned, stronger pipe or special installation procedures where recommended trench widths are exceeded. The cost of redesign, stronger pipe, or special installation procedures will be borne by the contractor without any additional cost to the U.S. Government.

A-3.1.1.1 Bottom Preparation

The bottoms of trenches will be accurately graded to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Bell holes will be excavated to the necessary size at each joint or coupling to eliminate point bearing. Stones of 50 mm (2 in) or greater in any dimension, or as recommended by the pipe/conduit manufacturer, whichever is smaller, will be removed to avoid point bearing.

A-3.1.1.2 Removal of Unyielding Material

Where over-depth is not indicated and unyielding material is encountered in the bottom of the trench, such material will be removed to a depth of four in below the required grade and replaced with suitable materials as provided in Paragraph A-3.3 (Backfilling and Compaction).

A-3.1.1.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, such material will be removed to the depth directed and replaced to the proper grade with select granular material as provided in Paragraph A-3.3 (Backfilling and Compaction). When removal of unstable material is required due to the contractor's fault or neglect in performing the work, the resulting material will be excavated and replaced by the contractor without additional cost to the U.S. Government.

A-3.1.1.4 Excavation for Appurtenances

Excavation for maintenance holes, catch basins, inlets, or similar structures will be sufficient to leave at least 600 mm (12 in) clear between the outer structure surfaces and the face of the excavation or support members. Rock will be cleaned of loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as directed. Loose, disintegrated rock and thin strata will be removed. Removal of unstable material will be as specified above. When concrete or masonry is to be placed in an excavated area, special care will be taken not to disturb the bottom of the excavation. Excavation to the final grade level will not be made until just before the concrete or masonry is to be placed.

A-3.1.1.5 Jacking, Boring, and Tunneling

Unless otherwise indicated, excavation will be by open cut except that sections of a trench may be jacked, bored, or tunneled if, in the opinion of the U.S. Government representative, the pipe, cable, or duct can be safely and properly installed, and backfill can be properly compacted in such sections.

A-3.1.2 Stockpiles

Stockpiles of satisfactory, unsatisfactory and wasted materials will be placed and graded as specified. Stockpiles will be kept in a neat and well-drained condition, giving due consideration to drainage at all times. The ground surface at stockpile locations will be cleared, grubbed, and sealed by rubber-tired equipment. Excavated satisfactory and unsatisfactory materials will be stockpiles separately. Stockpiles of satisfactory materials will be protected from contamination that may destroy the quality and fitness of the stockpiled material. If the contractor fails to protect the stockpiles and any material becomes unsatisfactory, such material will be removed and replaced with satisfactory material from approved sources at no additional cost to the U.S. Government. Locations of stockpiles of satisfactory materials will be subject to prior approval of the U.S. Government representative.

A-3.2 Backfilling and Compaction

Backfill material will consist of satisfactory material, select granular material, or initial backfill material as required. Backfill material will be placed in layers, and each layer will be compacted. Backfill within 150 mm (6 in of the conduit will be free of solid matter greater than 50-mm (2-in) maximum dimension or having sharp edges likely to damage the conduits.

A-3.2.1 Trench Backfill

Trenches will be backfilled to the grade shown, but will not be backfilled until the U.S. Government has inspected the conduit installation and encasement.

A-3.2.1.1 Replacement of Unyielding Material

Unyielding material removed from the bottom of the trench will be replaced with select granular material or initial backfill material.

A-3.2.1.2 Replacement of Unstable Material

Unstable material removed from the bottom of the trench or excavation will be replaced with select granular material placed and tamped in layers not exceeding 6-in loose thickness.

A-3.2.1.3 Bedding

Bedding will be of the type and thickness shown. The bedding will consist of undisturbed, tamped, or relatively smooth earth. If needed, the bedding will be placed in layers not exceeding 150-mm (6-in) loose thickness for compaction by hand-operated machine compactors, and 200-mm (8-in) loose thickness for other than hand-operated machines, unless otherwise specified. Each layer will be compacted to at least 95-percent maximum density for cohesionless soils and 90-percent maximum density for cohesive soils, unless otherwise specified.

A-3.2.1.4 Initial Backfill

Initial backfill material will be placed and compacted with approved tampers to a height of at least 300 mm (1 ft) above the utility pipe or conduit. Backfill will be placed in layers not exceeding 15-mm (6-in) loose thickness for compaction by hand-operated machine compactors, and 200-mm (8-in) loose thickness for other than hand-operated machines, unless otherwise specified. The backfill will be brought up evenly on both sides of the pipe for the full length of the pipe. Care will be taken to ensure thorough compaction of the fill under the haunches of the pipe. Each layer will be compacted to at least 95-percent maximum density for cohesionless soils and 90-percent maximum density for cohesive soils, unless otherwise specified.

A-3.2.1.5 Final Backfill

The remainder of the trench, except for special materials for roadways, railroads and airfields, will be filled with satisfactory material. Backfill material will be placed and compacted as follows:

a. Roadways, Railroads, and Airfields: Backfill will be placed up to the elevation of paving. Water flooding or jetting methods of compaction will not be permitted.

b. Sidewalks, Turfed, or Seeded Areas and Miscellaneous Areas: Backfill will be deposited in layers of a maximum of 300-mm (12-in) loose thickness and compacted to 85-percent maximum density for cohesive soils and 90-percent maximum density for cohesion-less soils. Water flooding or jetting methods of compaction will be permitted for granular non-cohesive backfill material. Water jetting will not be allowed to penetrate the initial backfill. Compaction by water flooding or jetting will not be permitted. This requirement will also apply to all other areas not specifically designated above.

A-3.2.2 Backfill for Appurtenances

After the maintenance hole, basin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for three days, backfill will be placed in such a manner that the structure will not be damaged by the shock of falling earth. The backfill material will be deposited and compacted as specified for final backfill and will be brought up evenly on all sides of the structure to prevent eccentric loading and excessive stress.

A-3.3 Special Requirements

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

a. Plastic Marking Tape: Warning tapes will be installed directly above the pipe, at least 300 mm (12 in) above the pipe, but not to exceed the depth in the manufacturer's recommendations.

b. Testing will be the responsibility of the contractor and will be performed at no additional cost to the U.S. Government.

c. Testing Facilities: Tests will be performed by an approved commercial testing laboratory or may be tested by facilities furnished by the contractor. No work requiring testing will be permitted until the facilities have been inspected and approved by the U.S. Government representative. The first inspection will be at the expense of the U.S. Government. Cost incurred for any subsequent inspection required because of failure of the first inspection will be charged to the contractor.

A-3.4 Testing of Backfill Materials

Classification of backfill materials will be determined IAW ASTM D 2487-00, and the moisture-density relations of soils will be determined IAW ASTM D 1557-91. A minimum of one soil classification and one moisture-density relation test will be performed on each different type of material used for bedding and backfill.

APPENDIX B. EUROPEAN THEATRE-UNIQUE DESIGN CONSIDERATIONS

B-1.0 EUROPEAN THEATRE-UNIQUE DESIGN CONSIDERATIONS

For projects in the European Theater, the 5th Signal Command has requested the following modifications from the standards as specified in the OSPDPR.

B-1.1 Fiber-Patch Panels

The standard fiber-patch panels will be a one rack-unit high, 24-port, SC fiber-patch panel. Type SC connectors are to be used for terminating fiber cables, unless the 5th Signal Command approves ST connectors for a specific EUB.

B-1.2 Equipment Cabinets

The standard equipment cabinet that will be used in all core locations will be floor-mounted and be 0.8 m (depth) x 0.8 m (width) x 2 m (height).

B-1.3 End User Buildings (EUB)

The EUBs classified as Tiers 1, 2, and 3 will be provided full connectivity, to include copper and fiber cabling, as well as edge switches.

B-1.4 EUB Protected Entrance Terminal Connectivity

A PET, sized to match the OSP cable run to the, will be installed. The PET will be equipped with protected, line sharing adapter (LSA)+ terminal blocks. Another LSA+ terminal block (unprotected) will be installed in an equipment cabinet, typically where the current and/or proposed network equipment will be placed. If I3MP is not implementing any data electronics or data cabinets in an EUB, the unprotected LSA+ will be installed adjacent to the PET's LSA+. A house cable will be installed from the PET to the equipment cabinet where the network equipment resides or is proposed, sized to match the new OSP cable. These house cables will be in compliance with European specifications and will be terminated at the LSA+ disconnect terminals at both the PET and in the equipment cabinets. If I3MP is not implementing any data electronics or data cabinets in an EUB, the house cable will be run from the PET to the adjacent, unprotected LSA+. Figure B-1 depicts a typical PET, collocated with the new equipment cabinet.

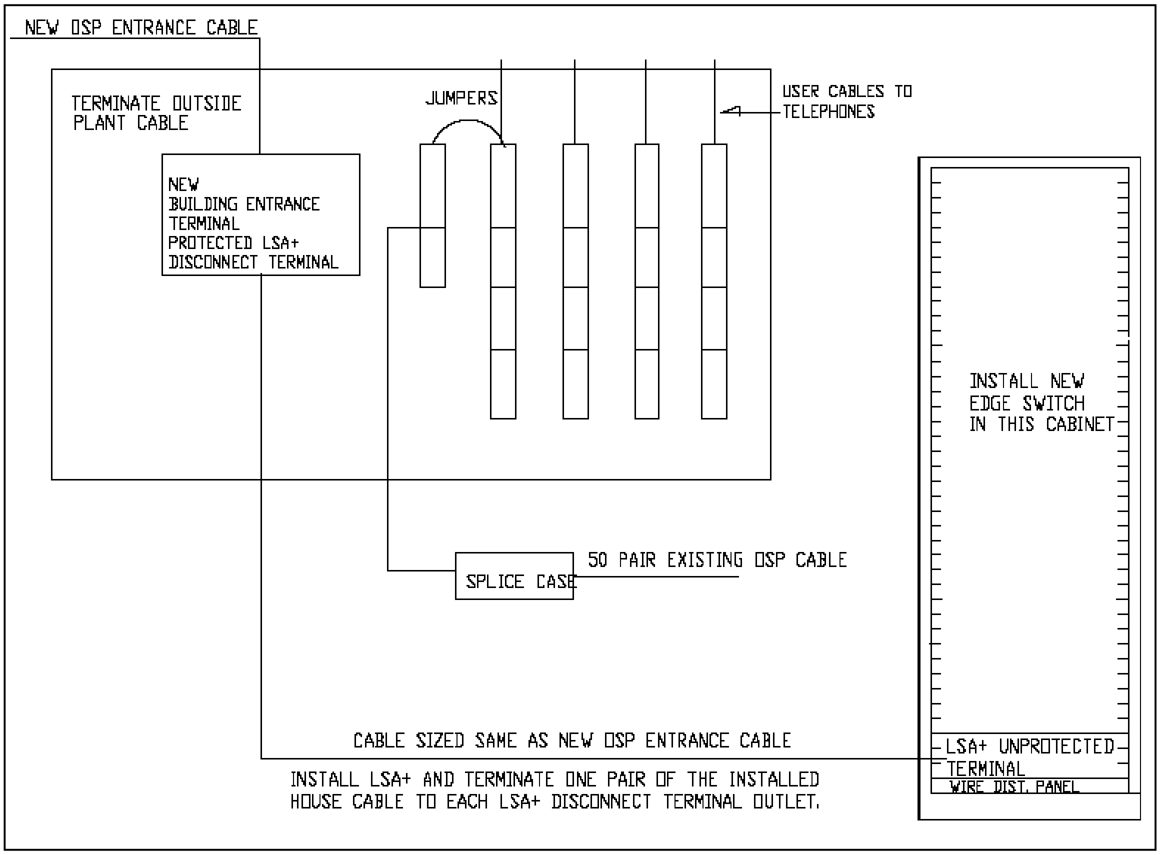


Figure B-1. Typical PET

If the existing, internal-building wiring terminates in another location greater than 7 m (20 ft) from the I3MP equipment cabinet, another house cable will be installed from the new I3MP cabinet (terminated into the cabinet's LSA+ disconnect terminal) to this other location. This house cable will be terminated in another, unprotected LSA+, in a location adjacent to the existing termination location, where possible. The size of this house cable should be determined as follows:

a. If the new building entry cable is 100 pairs or less, the house cable will be sized the same as the new entry cable.

b. If the new entry cable is greater than 100 pairs, the house cable will be sized to accommodate all of the existing drops terminated on the existing backboard, plus 25-percent sparing. This house cable will never exceed the size of the new entry cable. If the contractor has any question regarding the sizing of this house cable for a specific building, they will direct the question to the site's IPT lead for resolution.

Figure B-2 depicts a typical configuration for where the existing building wiring is not terminated in the same location as the new I3MP data cabinet.

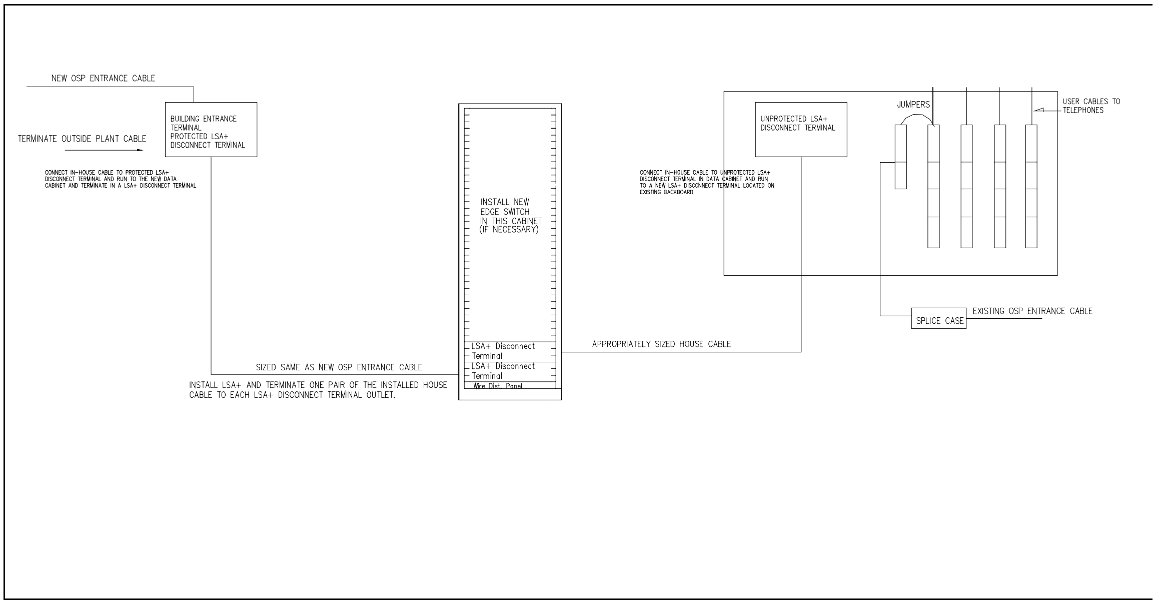


Figure B-2. Cabling from New Location to Existing Location

B-1.5 Outside Terminals

An outside PET, sized to match the OSP cable run to the outside terminal, will be installed. The PET will be equipped with protected, LSA+ terminal blocks. Another LSA+ terminal block (unprotected) will be installed adjacent to the PET and a cable or jumper wire will be installed to connect the two terminals. The same configuration will be used for pole- or pedestal-mounted terminals. Figure B-3 depicts a typical outside terminal configuration.

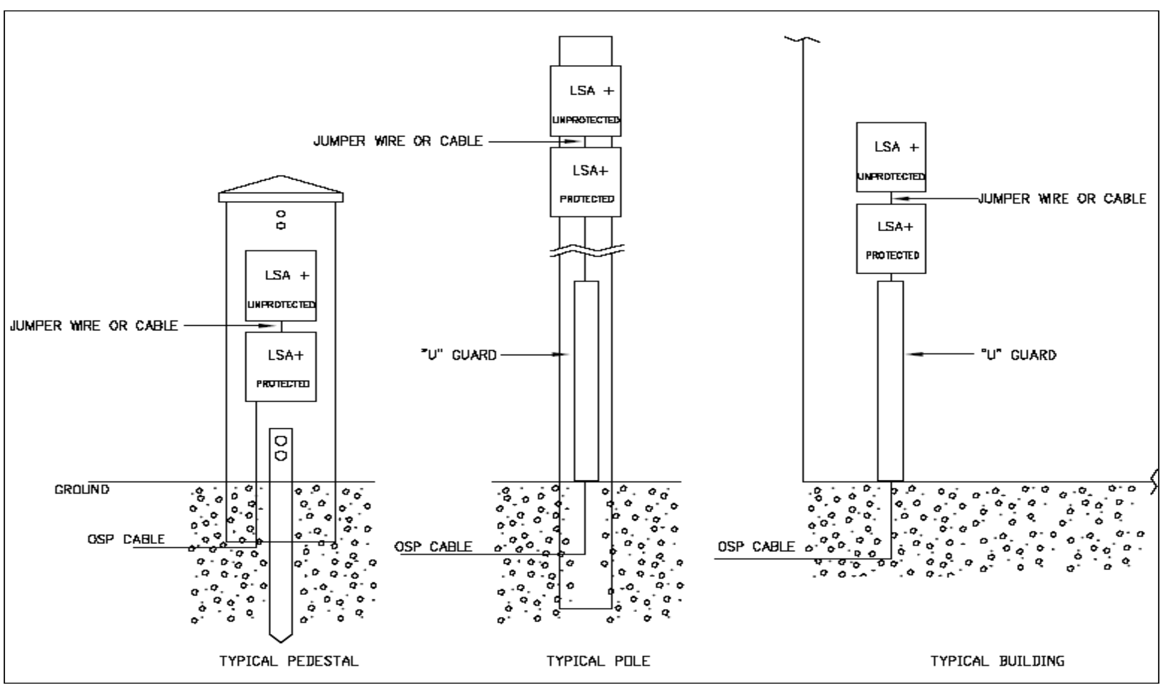


Figure B-3. Outside PET

B-1.6 EUB Grounding

Reference the USAISEC-FDED *Grounding and Bonding Guidance* document for general guidance. The European ground cable color code is green with yellow stripe.

B-1.7 Hardened Carrier Distribution System (HCDS)

An HCDS will be implemented, as detailed in the EDP, but will only include the HCDS, the fiber, and a lock box or cabinet. No electronics will be provided as part of this HCDS design. The HCDS hand holes and maintenance holes will be considered part of the HCDS system and are expected to be fully compliant with National Security Telecommunications and Information Systems Security Instruction (NSTISSI) 7003. Specifically, the walls of the installed HCDS hand holes and/or maintenance holes will meet or exceed the minimum requirements for encasing the HCDS.

B-1.8 European Cabling

All multi-pair copper cable installed between buildings will be waterproof, IAW DIN VDE 0815 and 0816. The copper conductor size will be 0.6-mm diameter. Commercially available, industry standard cables will be type A-02YSOF(L)2Y...x2x0.6 ST III BD (the … denotes the pair count). When entering a building that requires tipping cables, appropriately-sized J-2Y(ST)Y…x2x 0.6 St III BD will be used.

B-1.9 MDF/Intermediate Distribution Frame (IDF) Standard Termination Block

The 200-pair, 5,000-series termination block will be used as the standard termination on MDFs/IDFs.

B-1.10 OSP Fiber Sparing

Adequate spare FOC will be provided in the maintenance hole and duct system to allow future connection of all Tier-4 buildings, but not less than 25-percent sparing of installed FOC.

B-1.11 Global Information Grid (GIG)/Defense Information Infrastructure (DII)/Tech Control Facilities

The GIG/DII/Tech Control Facilities will be dual-homed (via either redundant paths or one concrete-encased path) and receive 48 strands of single-mode fiber to the DCO facility.

APPENDIX C. NORTH AMERICA AND EUROPEAN DRAWINGS

Figures C-1 to C-11 show the North America and European drawings.

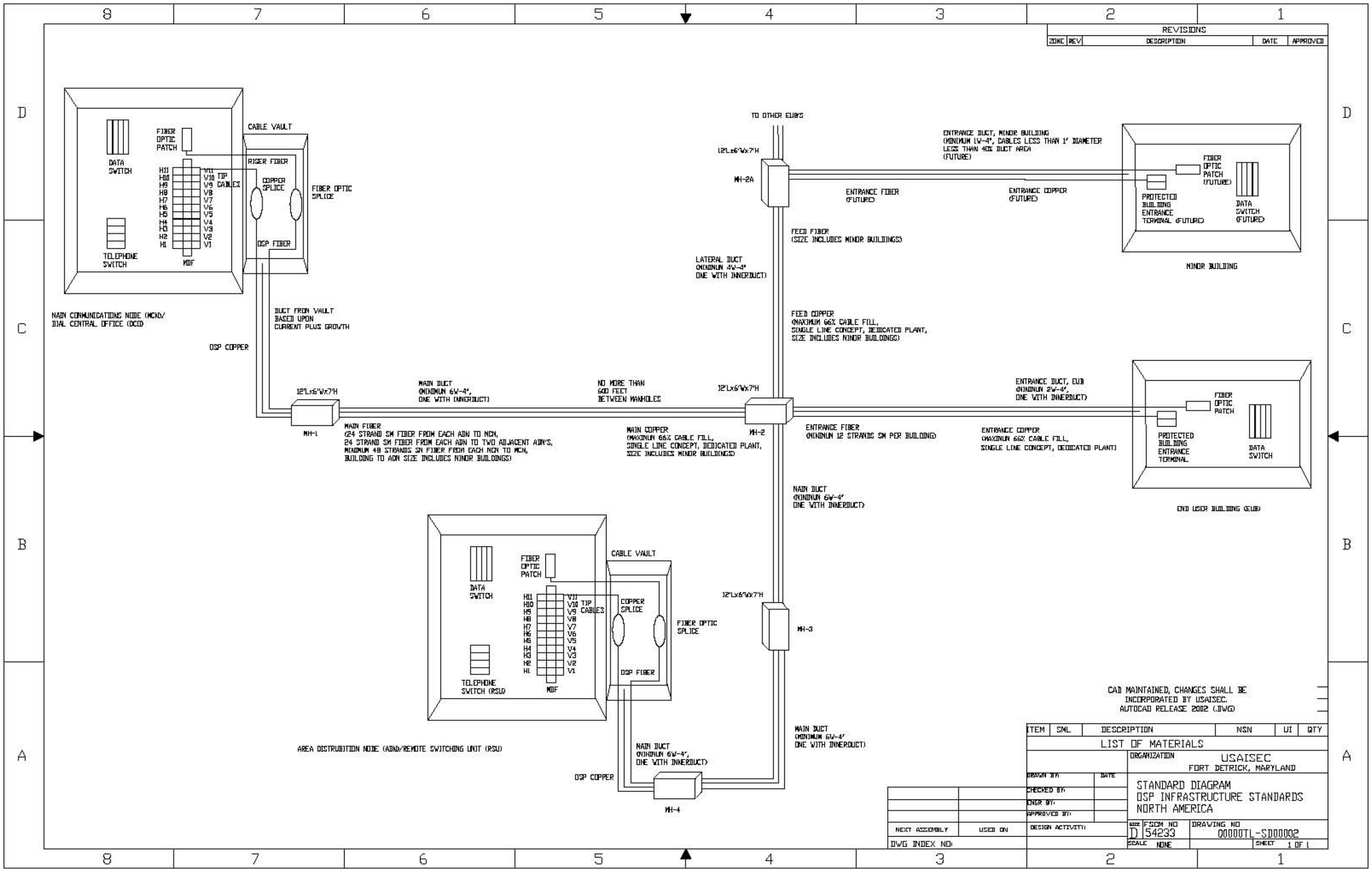


Figure C-1. OSP Infrastructure Standards – North America

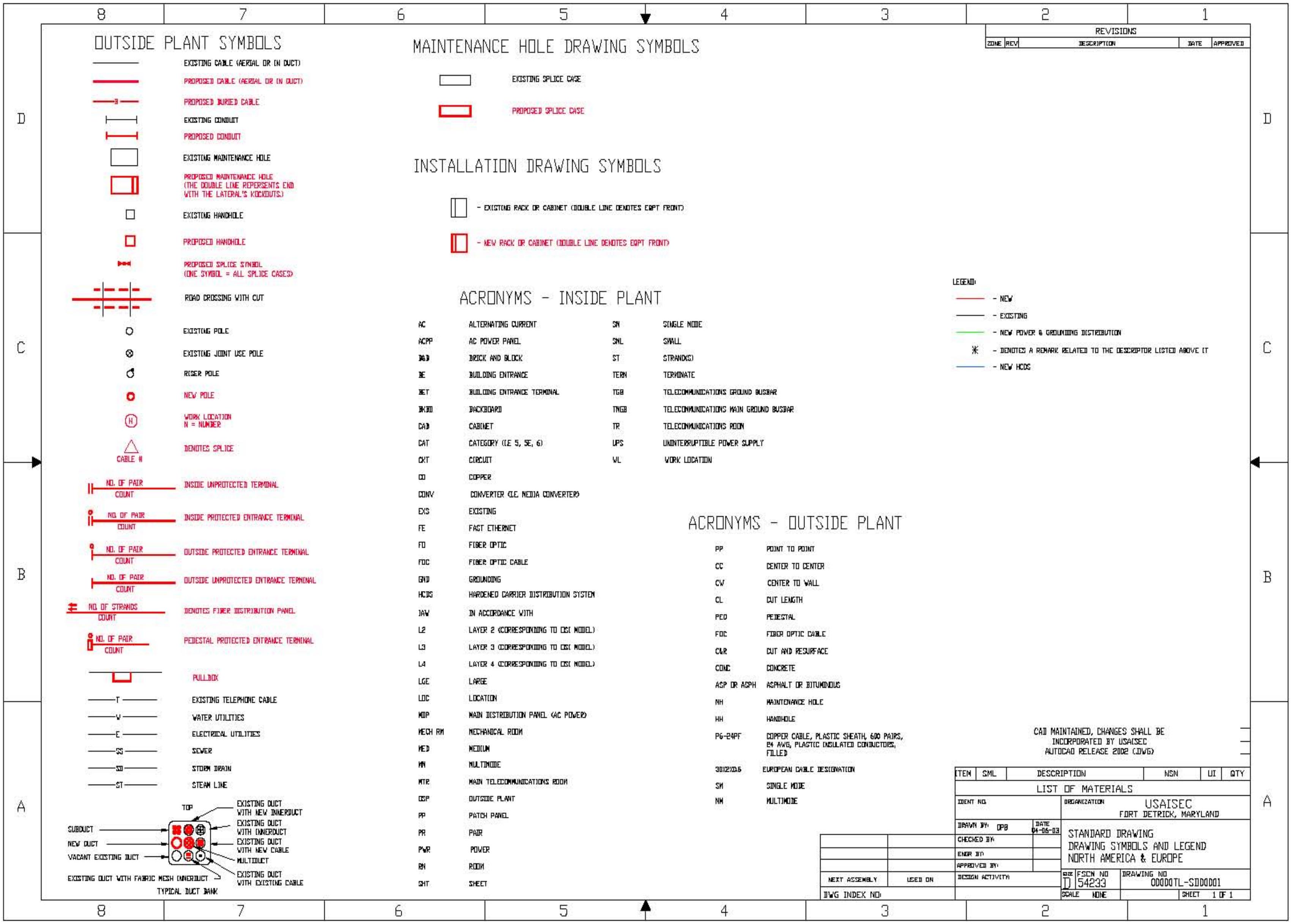


Figure C-2. Drawing Symbols – North America and Europe

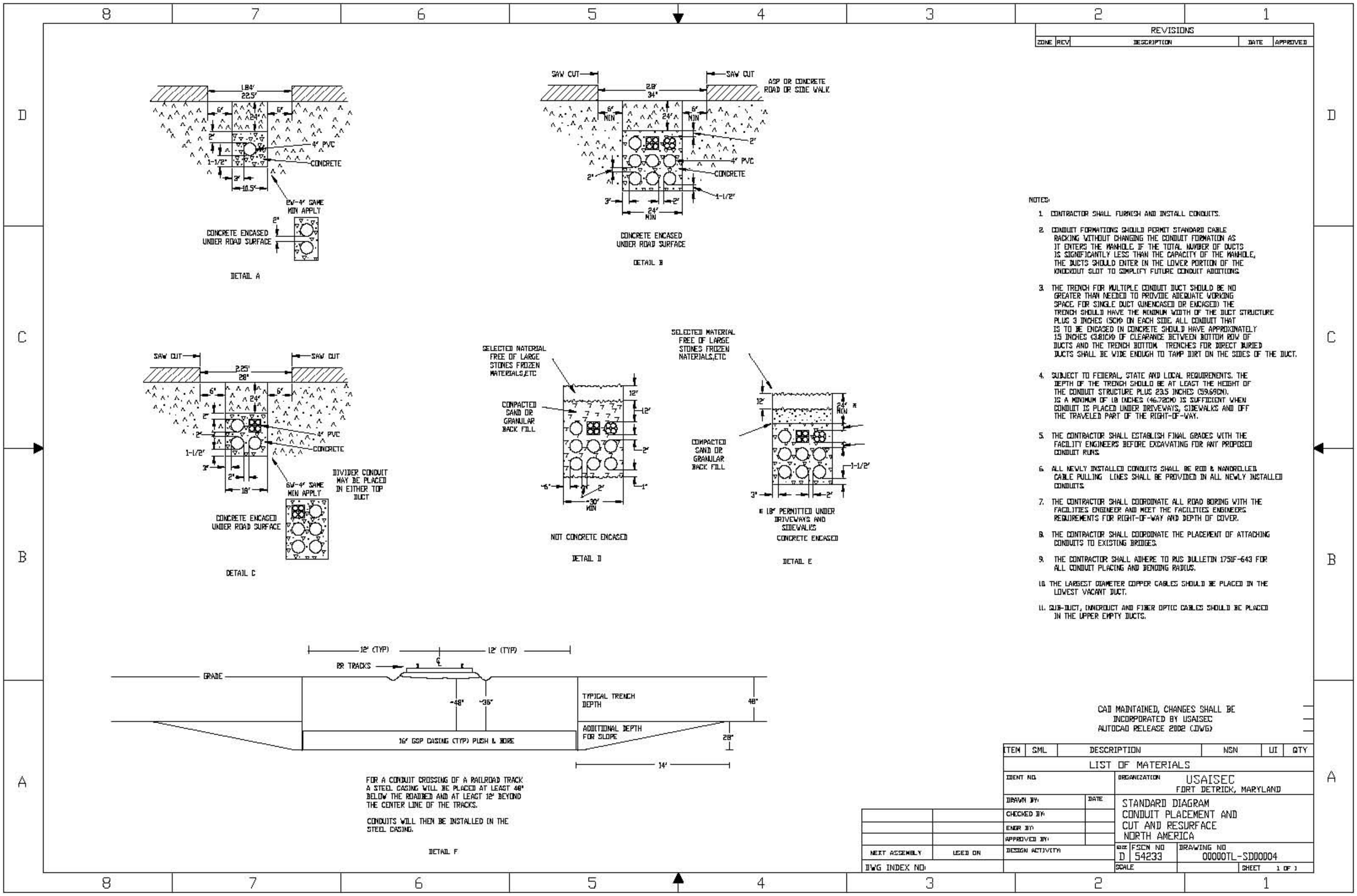


Figure C-3. Conduit Placement/Cut and Resurface – North America

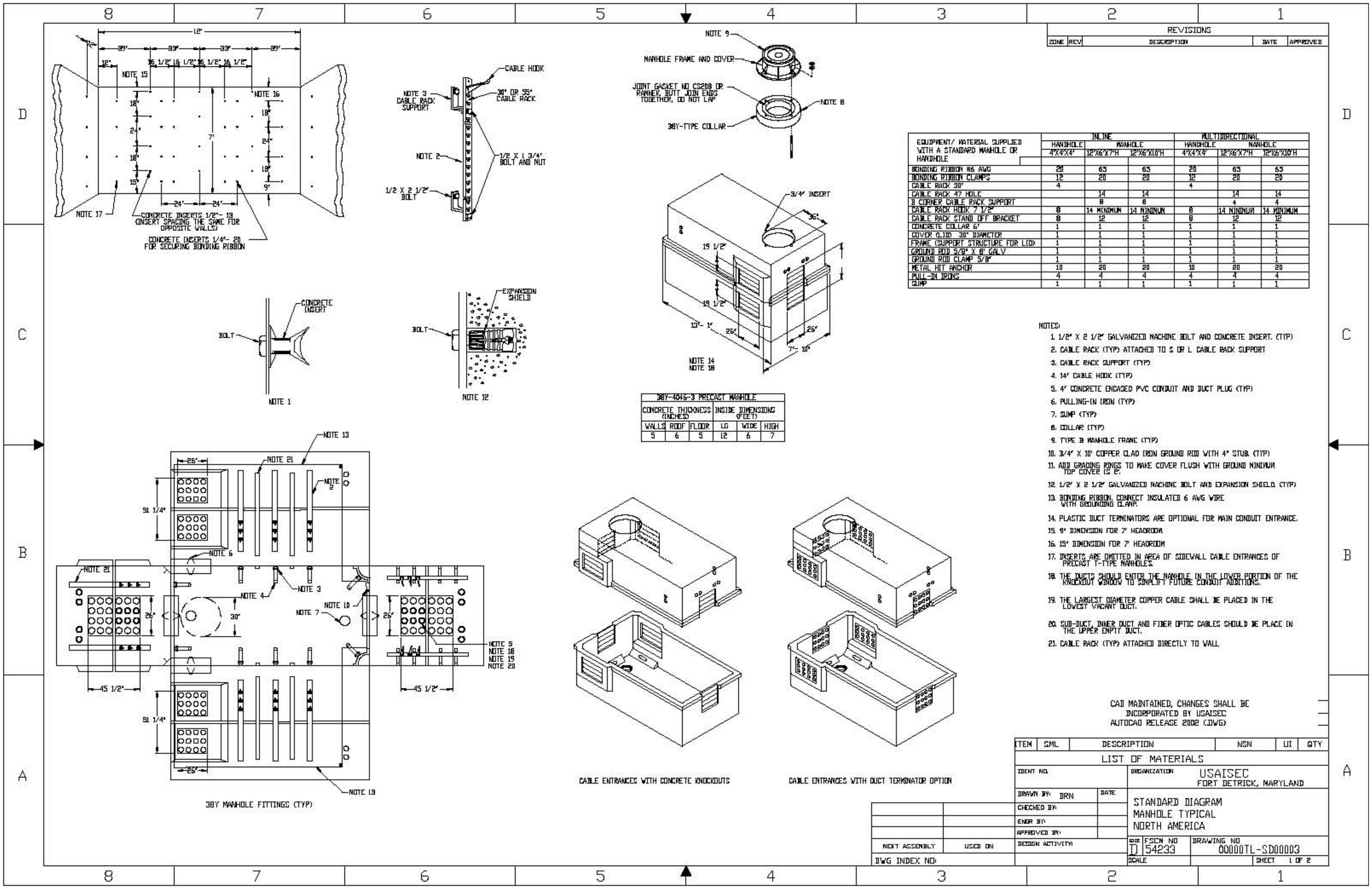


Figure C-4. Typical Maintenance Hole – North America

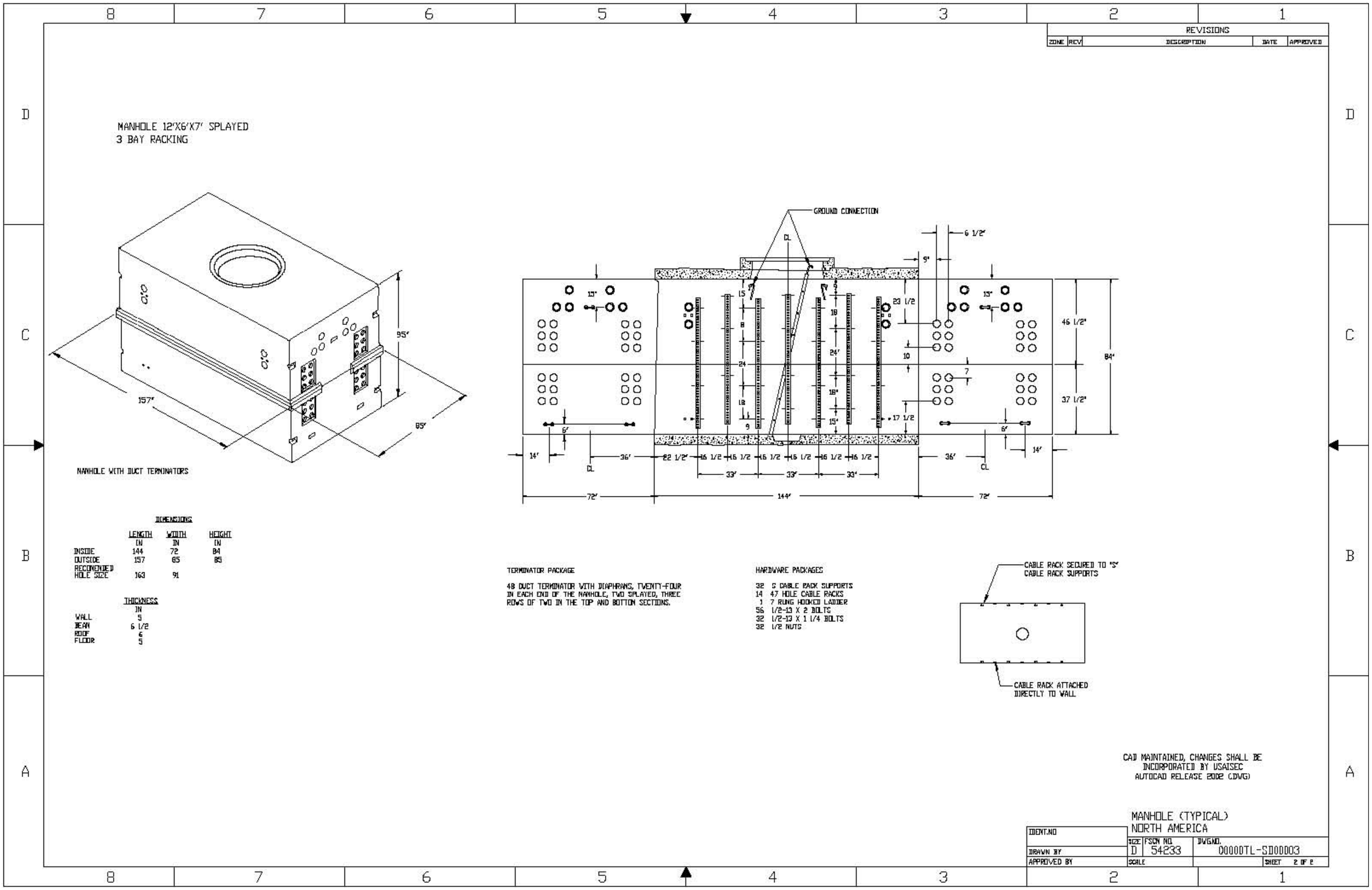


Figure C-4. Typical Maintenance Hole – North America (continued)

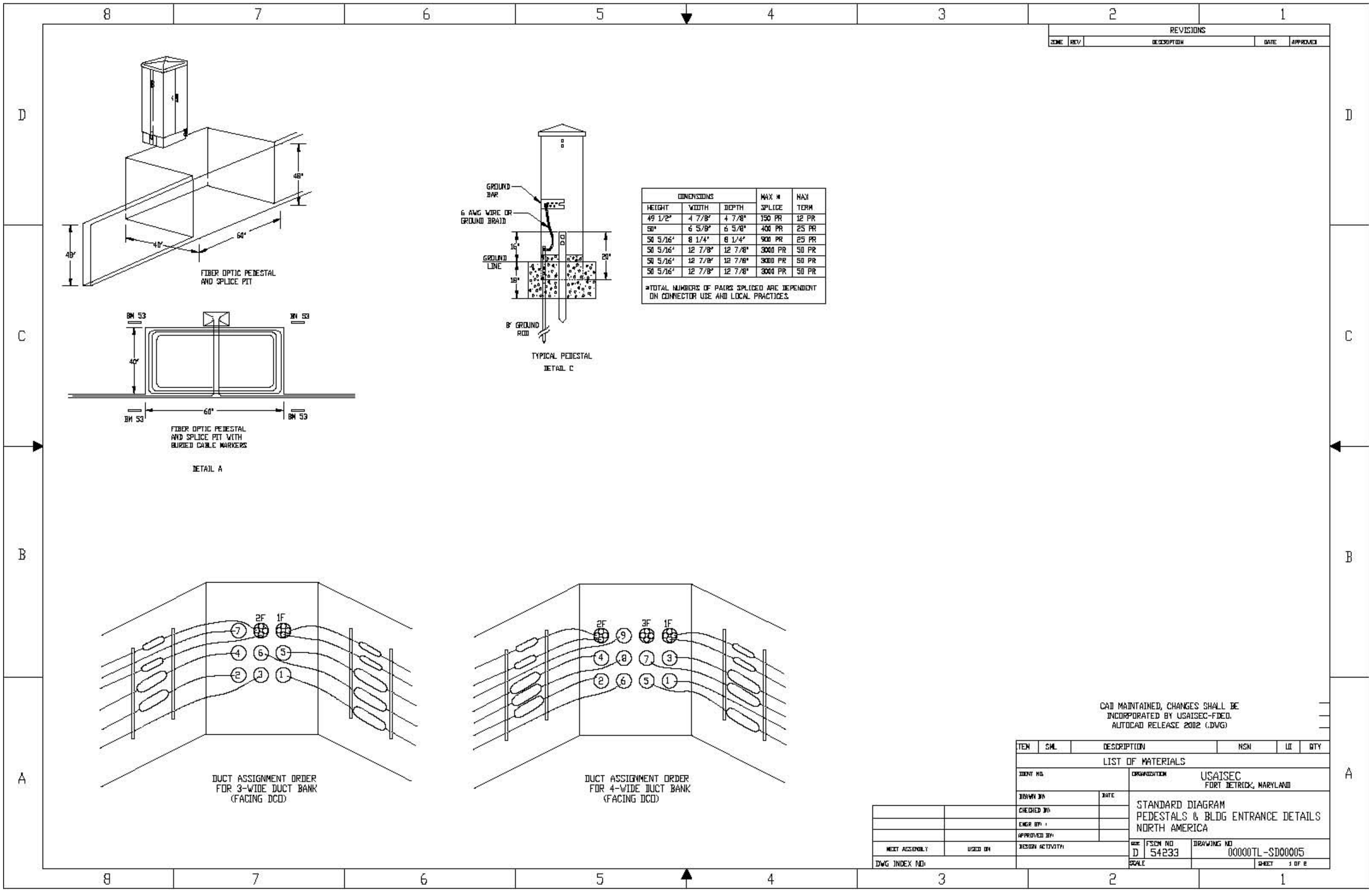


Figure C-5. Pedestals and Building Entrance Details – North America

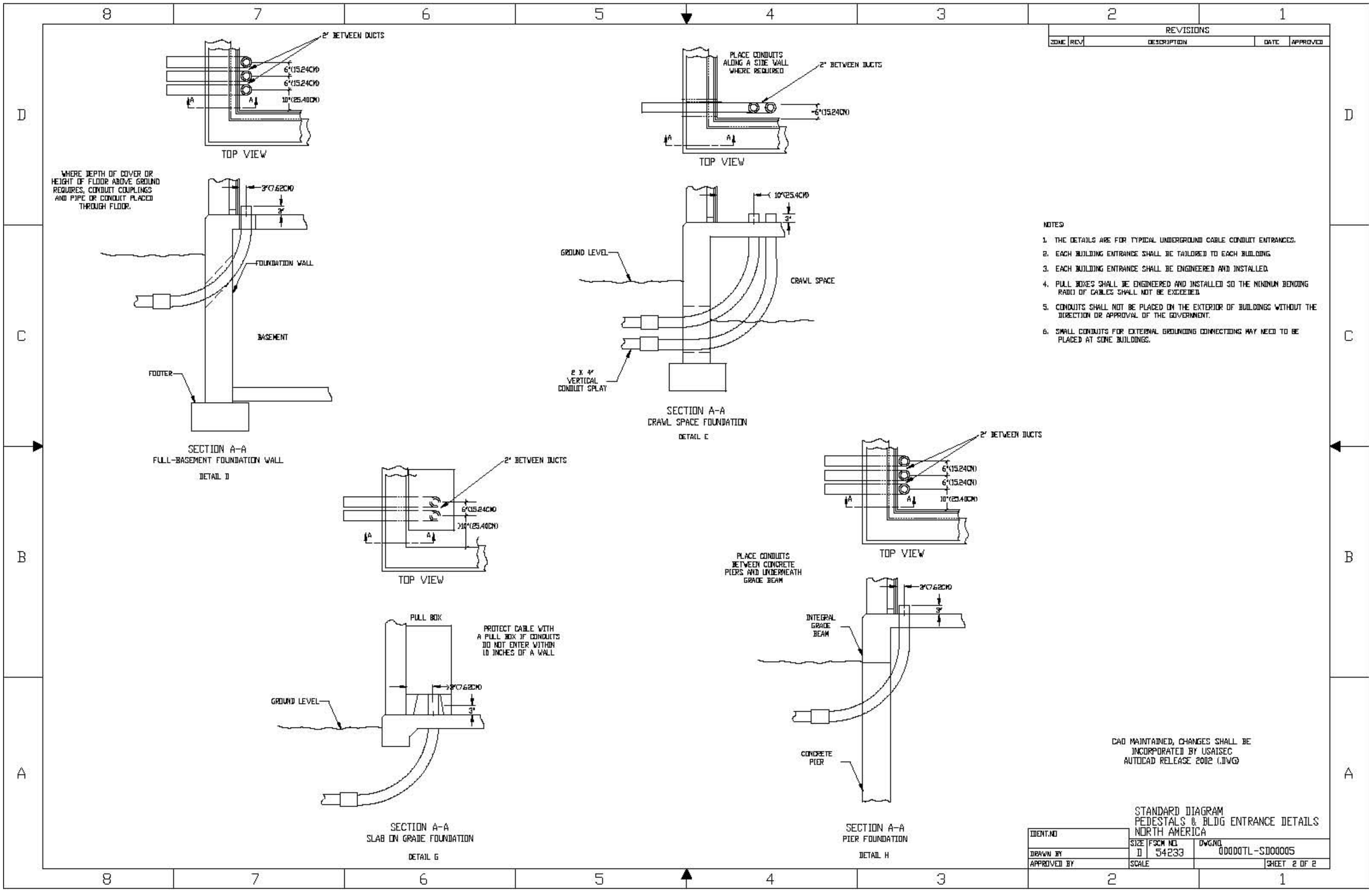


Figure C-5. Pedestals and Building Entrance Details – North America (continued)

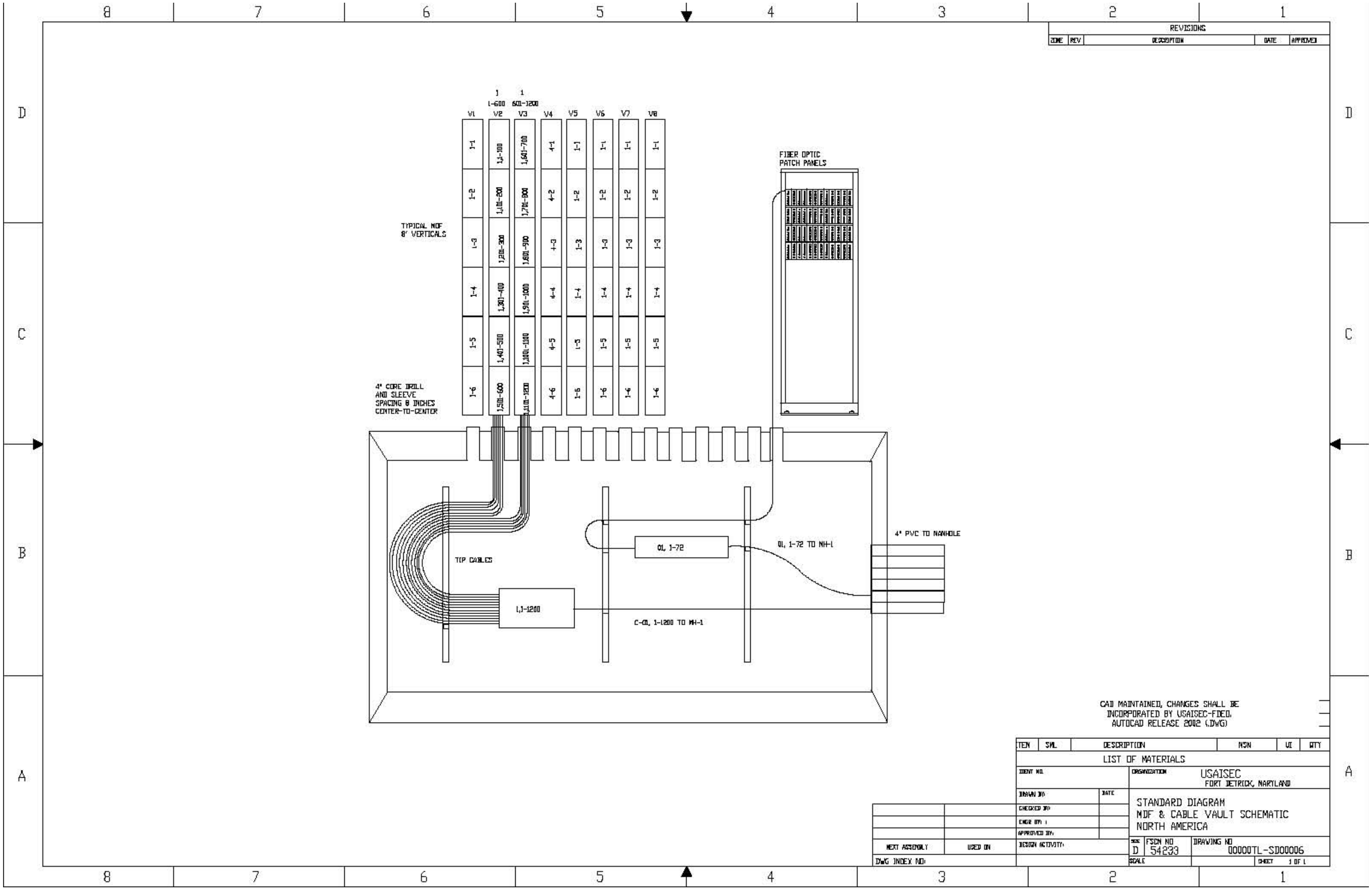


Figure C-6. MDF and Cable Vault Schematic – North America

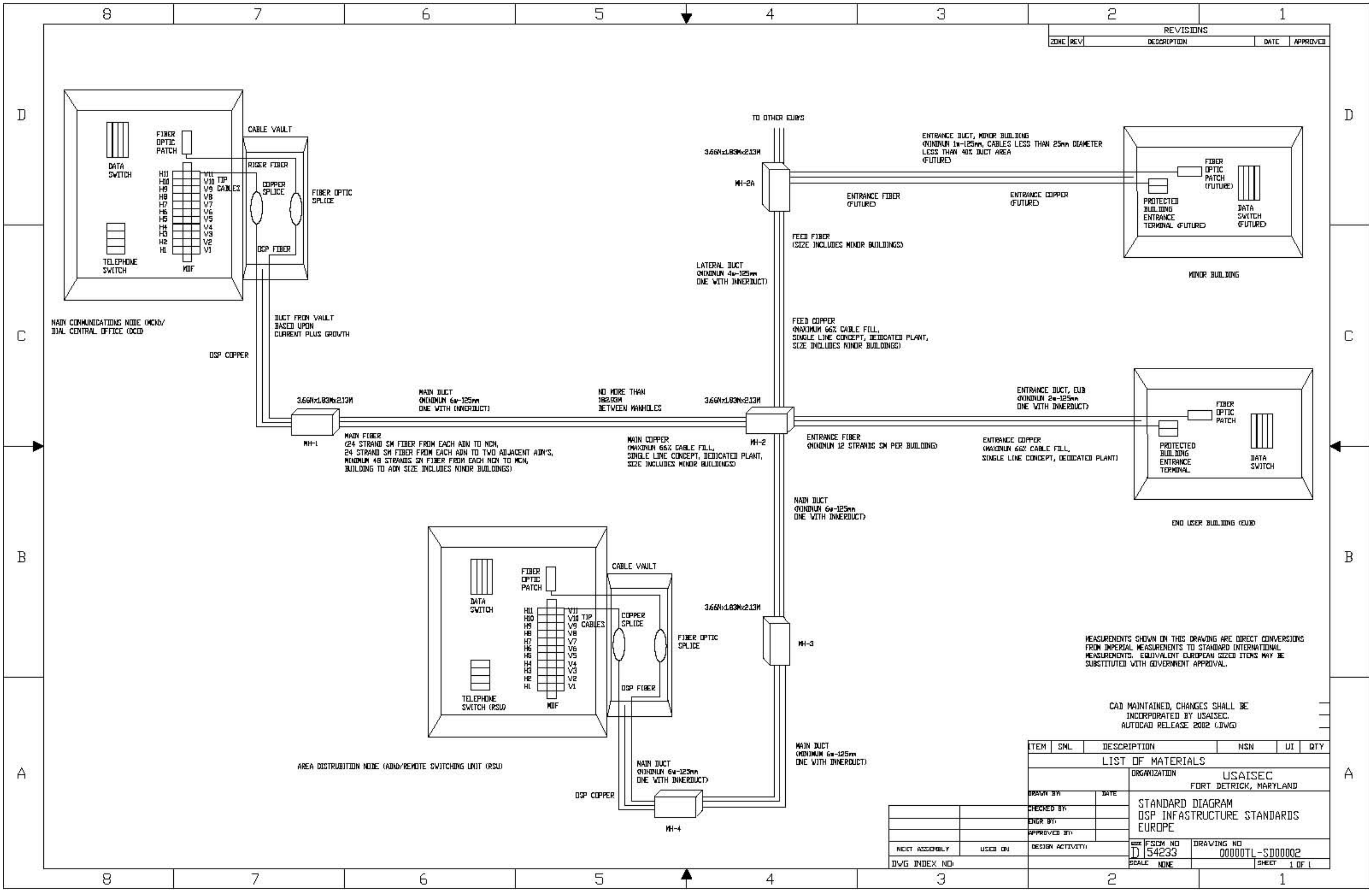


Figure C-7. OSP Infrastructure Standards – Europe

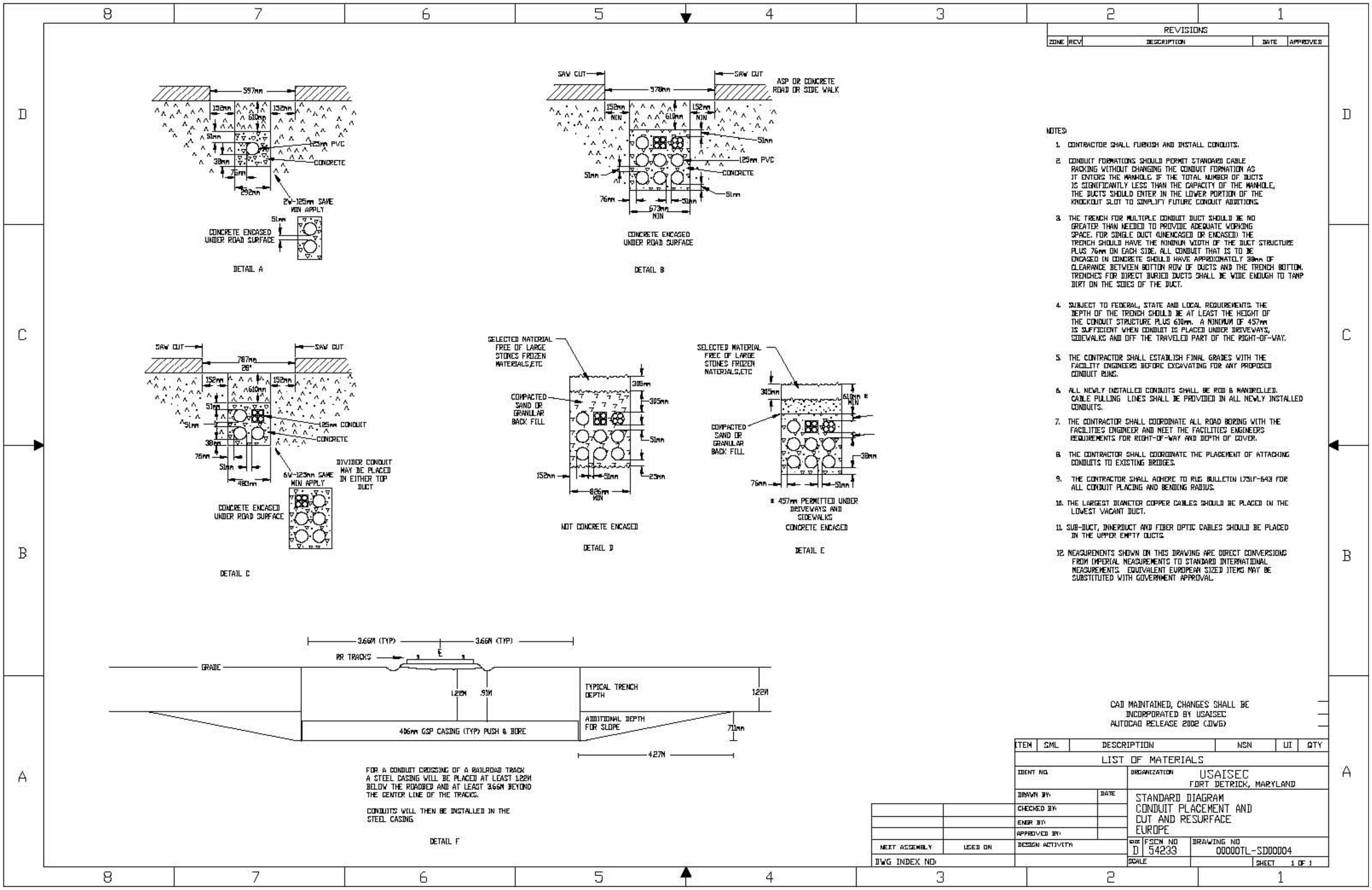
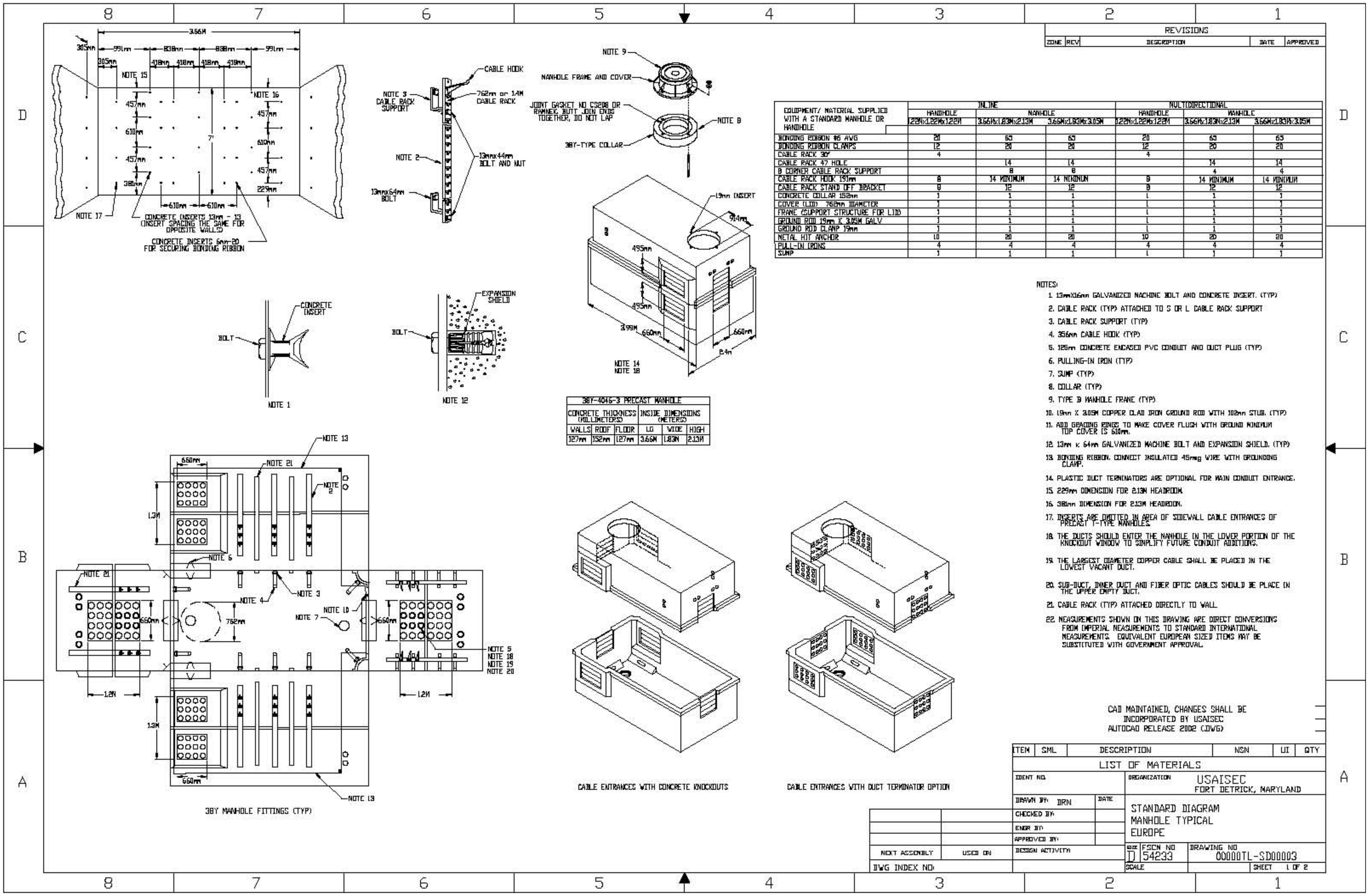
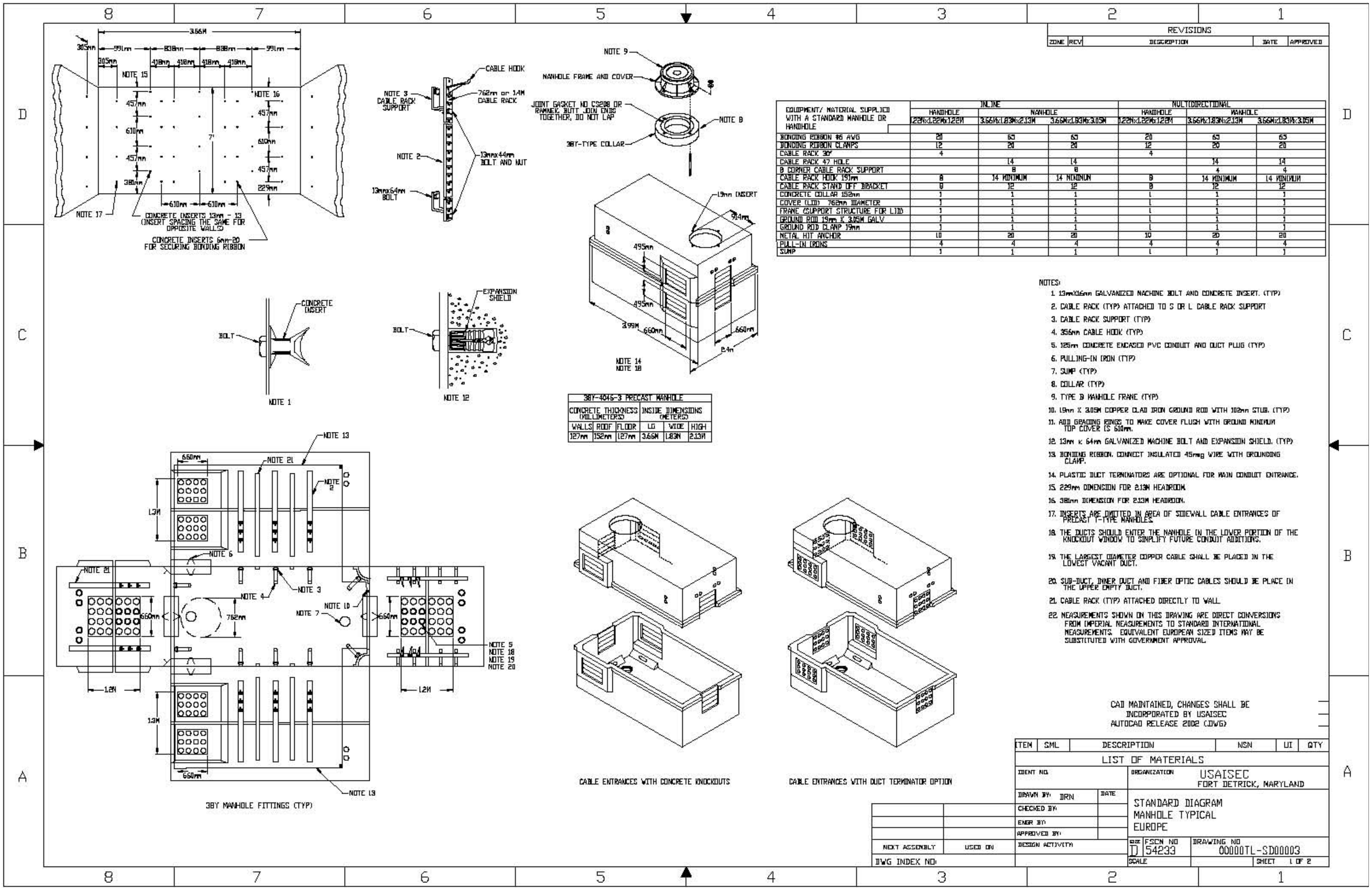


Figure C-8. Conduit Placement/Cut and Resurface – Europe



EQUIPMENT/ MATERIAL SUPPLIED WITH A STANDARD MANHOLE OR HANDHOLE	INLINE HANDHOLE 1.22Mx1.22Mx1.22M	INLINE MANHOLE 3.66Mx1.83Mx2.13M	INLINE MANHOLE 3.66Mx1.83Mx3.05M	MULTIDIRECTIONAL HANDHOLE 1.22Mx1.22Mx1.22M	MULTIDIRECTIONAL MANHOLE 3.66Mx1.83Mx2.13M	MULTIDIRECTIONAL MANHOLE 3.66Mx1.83Mx3.05M
BONDING RIBBON #6 AWG	20	65	65	20	65	65
BONDING RIBBON CLAMPS	12	20	20	12	20	20
CABLE RACK 30"	4			4		
CABLE RACK 47 HOLE		14	14		14	14
B CORNER CABLE RACK SUPPORT		8	8		4	4
CABLE RACK HOOK 191mm	8	14 MINIMUM	14 MINIMUM	8	14 MINIMUM	14 MINIMUM
CABLE RACK STAND OFF BRACKET	8	12	12	8	12	12
CONCRETE COLLAR 152mm	1	1	1	1	1	1
COVER (LID) 762mm DIAMETER	1	1	1	1	1	1
FRAME (SUPPORT STRUCTURE FOR LID)	1	1	1	1	1	1
GROUND ROD 19mm X 3.05M GALV	1	1	1	1	1	1
GROUND ROD CLAMP 19mm	1	1	1	1	1	1
METAL HIT ANCHOR	10	20	20	10	20	20
PULL-IN IRONS	4	4	4	4	4	4
SUMP	1	1	1	1	1	1

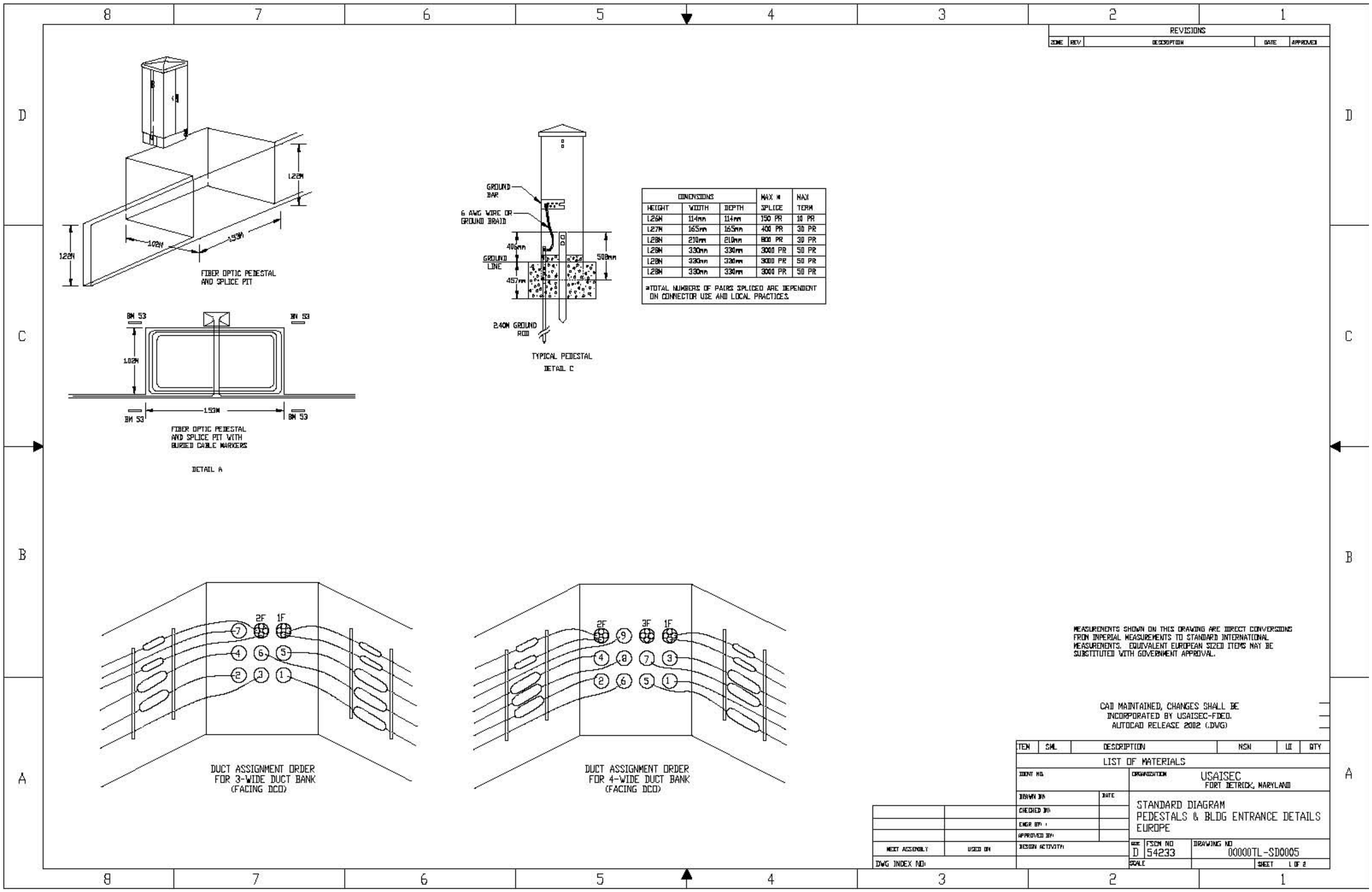
Figure C-9. Typical Maintenance Hole – Europe



EQUIPMENT/ MATERIAL SUPPLIED WITH A STANDARD MANHOLE OR HANDHOLE	INLINE HANDHOLE 1.22Mx1.22Mx1.22M	INLINE MANHOLE 3.66Mx1.83Mx2.13M	INLINE MANHOLE 3.66Mx1.83Mx3.05M	MULTIDIRECTIONAL HANDHOLE 1.22Mx1.22Mx1.22M	MULTIDIRECTIONAL MANHOLE 3.66Mx1.83Mx2.13M	MULTIDIRECTIONAL MANHOLE 3.66Mx1.83Mx3.05M
BONDING RIBBON #6 AWG	20	63	63	20	63	63
BONDING RIBBON CLAMPS	12	20	20	12	20	20
CABLE RACK 30"	4			4		
CABLE RACK 47 HOLE		14	14		14	14
B CORNER CABLE RACK SUPPORT		8	8		4	4
CABLE RACK HOOK 191mm	8	14 MINIMUM	14 MINIMUM	8	14 MINIMUM	14 MINIMUM
CABLE RACK STAND OFF BRACKET	8	12	12	8	12	12
CONCRETE COLLAR 152mm	1	1	1	1	1	1
COVER (LID) 762mm DIAMETER	1	1	1	1	1	1
FRAME (SUPPORT STRUCTURE FOR LID)	1	1	1	1	1	1
GROUND ROD 19mm X 3.05M GALV	1	1	1	1	1	1
GROUND ROD CLAMP 19mm	1	1	1	1	1	1
METAL HIT ANCHOR	10	20	20	10	20	20
PULL-IN IRONS	4	4	4	4	4	4
SUMP	1	1	1	1	1	1

38Y-4046-3 PRECAST MANHOLE					
CONCRETE THICKNESS (MILLIMETERS)			INSIDE DIMENSIONS (METERS)		
WALLS	ROOF	FLOOR	LG	WIDE	HIGH
127mm	152mm	127mm	3.66M	1.83M	2.13M

Figure C-9. Typical Maintenance Hole – Europe (continued)



DIMENSIONS			MAX * SPLICE	MAX TERM
HEIGHT	WIDTH	DEPTH		
1.26M	114mm	114mm	150 PR	10 PR
1.27M	165mm	165mm	400 PR	30 PR
1.28M	210mm	210mm	800 PR	30 PR
1.28M	330mm	330mm	3000 PR	50 PR
1.28M	330mm	320mm	3000 PR	50 PR
1.28M	330mm	330mm	3000 PR	50 PR

*TOTAL NUMBERS OF PAIRS SPLICED ARE DEPENDENT ON CONNECTOR USE AND LOCAL PRACTICES.

Figure C-10. Pedestals and Building Entrance Details – Europe

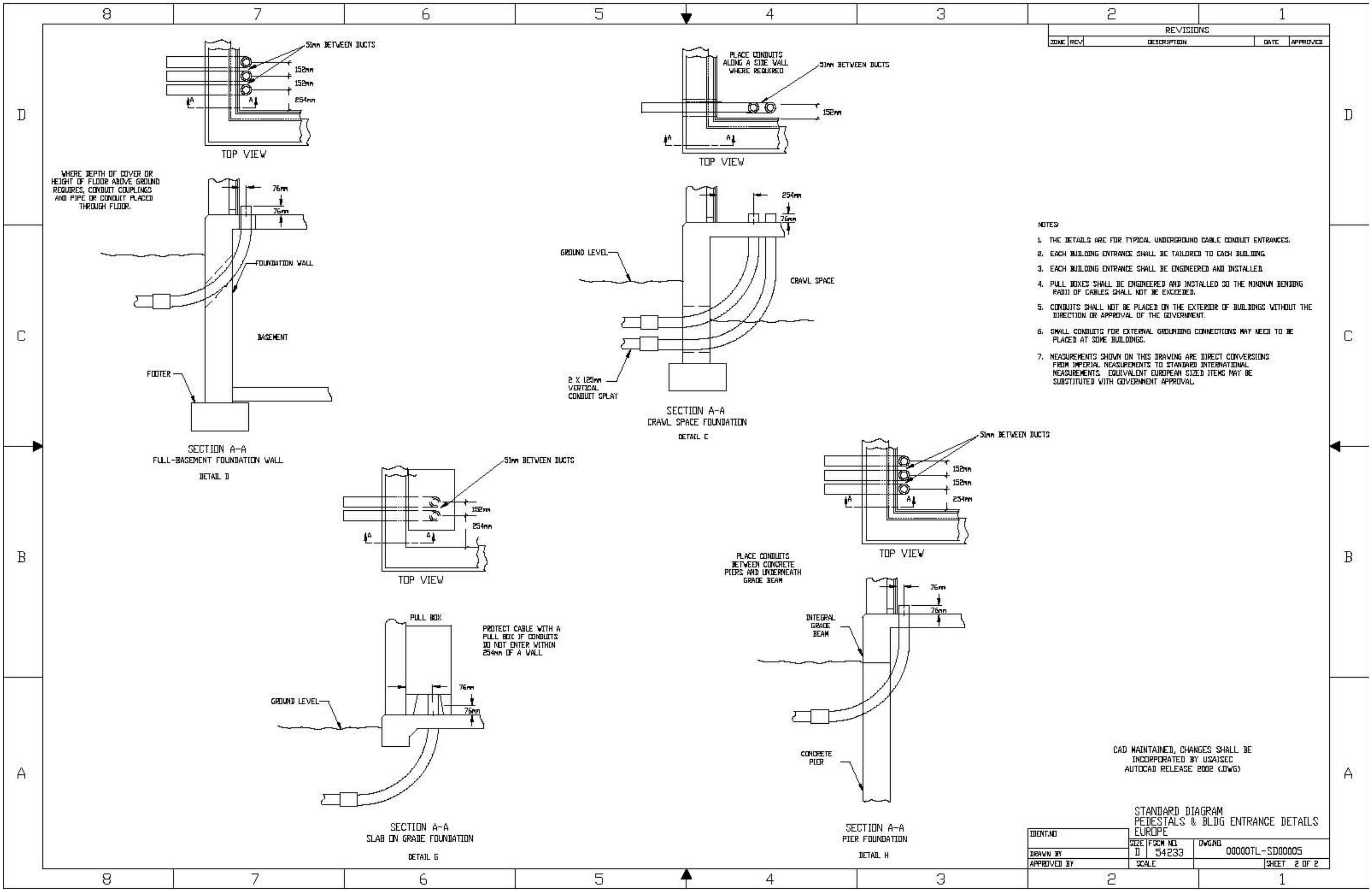


Figure C-10. Pedestals and Building Entrance Details – Europe (continued)

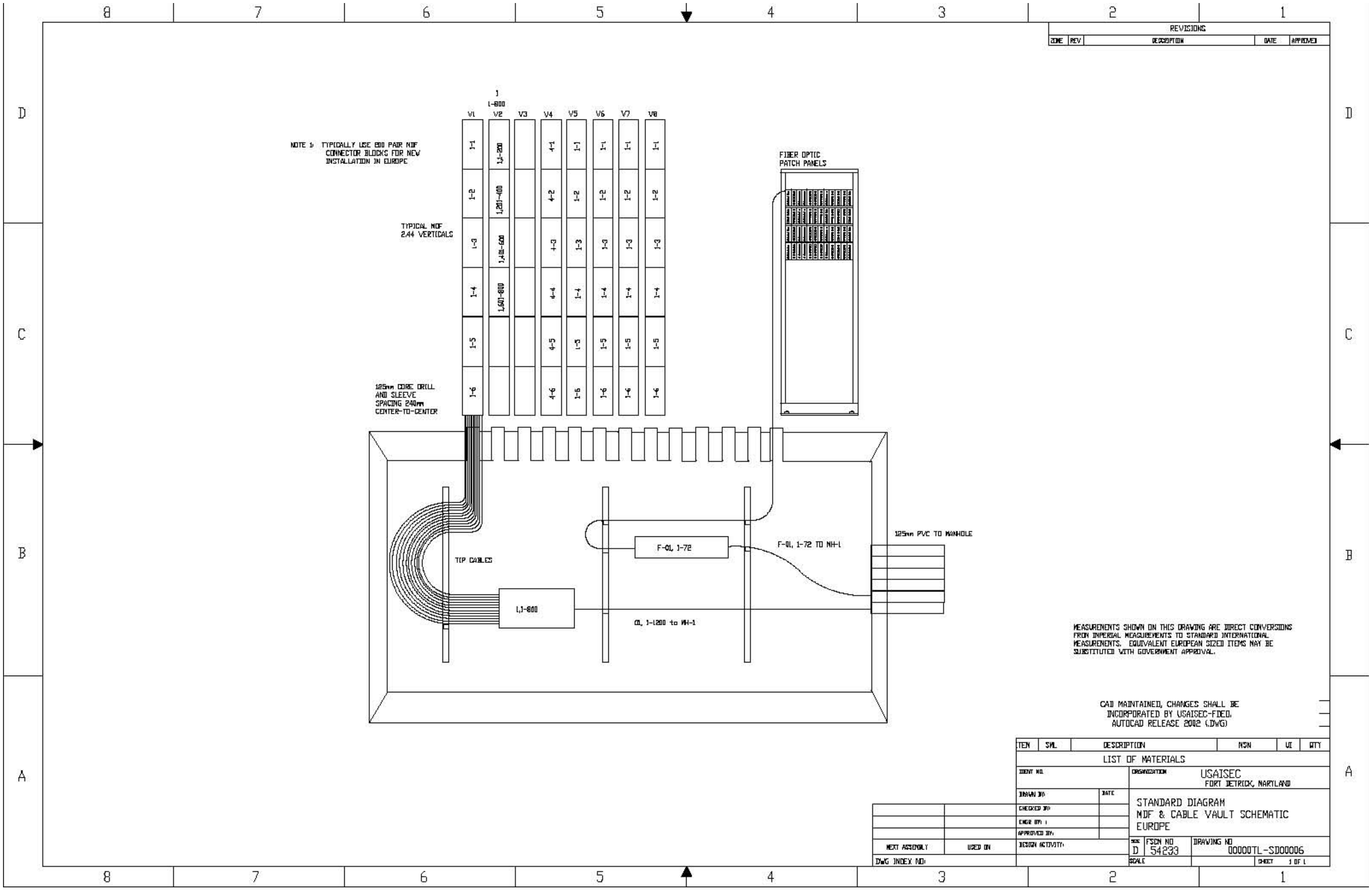


Figure C-11. MDF and Cable Vault Schematic – Europe

This page intentionally left blank

GLOSSARY. ACRONYMS AND ABBREVIATIONS

Ω	ohm
λ	wavelength
A/D	analog to digital
AC	alternating current
AD	Active Directory
ADD	addendum
ADRP	Army Defense Information Systems Network Router Program
AKM	Army Knowledge Management
amp	ampere
ANSI	American National Standards Institute
APD	avalanche photo diode
ASQC	American Society for Quality Control
ASTM	American Society for Testing and Materials
ATM	asynchronous transfer mode
AWG	American Wire Gauge
B-ISDN	broadband-integrated services digital network
BICSI	Building Industry Consulting Services, International
BORSCHT	battery feed, over-voltage protection, ringing, signaling, coding, hybrid, and testing
C	Celsius
C/C	center-to-center
cm^2	square centimeter
cm^3	cubic meter
CAD	Computer-aided Design
CDR	critical design review
CD-ROM	compact disk-read only memory
CO	Central Office
CO2	Carbon Dioxide
COT	central office terminal
CUITN	Common User Information Transport Network
D/A	digital to analog
dB	decibel
DB	direct-buried
DC	direct current
DCO	Dial Central Office
DCS	Defense Communications System
PM DCS-C	DCS-CONUS
PM DCS-E	DCS-Europe
PM DCS-P	DCS-Pacific
DDN	Defense Data Network
DII	Defense Information Infrastructure

DIN	Deutsches Instutut für Normung e.V.
DOD	Department of Defense
DOD	direct out dial
DPW	Directorate of Public Works
DS	digital signal
DSN	Defense Switched Network
DSSMP	Digital Switched Systems Modernization Program
DWDM	dense wave division multiplexing
EB	encased buried
EDP	Engineering Design Plan
EFI&T	engineer, furnish, install, and test
EIA/TIA	Electronic Industries Association/Telecommunications Industry Association
EMT	electrical-metallic tubing
ESM	Enterprise Systems Management
EUB	end user building
F	Farenheight
FDA	Food and Drug Administration
FDDI	fiber optic digital data interface
FDED	Fort Detrick Engineering Directorate
FM	Field Manual
FOC	fiber optic cable
FOPP	fiber optic patch panel
ft^2	square foot
GbE	Gigabit Ethernet
Gbps	gigabits per second
GHz	gigahertz
GIG	Global Information Grid
GPa	gigapascal
GSA	General Services Administration
GR	generic requirements
GSP	galvanized steel pipe
HCDS	Hardened Carrier Distribution System
HDD	horizontal directional drilling
HDPE	High Density Polyethylene
I2A2	Installation Information Assurance Architecture
I3A	Installation Information Infrastructure Architecture
I3MP	Installation Information Infrastructure Modernization Program
IA	Information Assurance
IAW	in accordance with
ID	identification
IDF	intermediate distribution frame

IDR	Initial Design Review
IEC	International Electrotechnical Commission
IEEE	Institute for Electrical and Electronics Engineers
ILD	injection laser diode
IMC	intermediate metal conduit
in^2	square inch
IPT	Integrated Product Team
ISO	International Standards Organization
km	kilometer
kPa	kilopascal
LAN	local area network
LED	light emitting diode
LSA	line sharing adapter
µm	micrometer
µs	microsecond
m	meter
MC	main cross-connect
MDF	main distribution frame
MGB	master ground bar
MH	maintenance hole
MHz	megahertz
MPD	multiple plastic duct
mm	millimeter
MMW	millimeter wave wireless
MULDEM	multiplexer, demultiplexer
MWG	Metric Wire Gauge
N	newton
N/A	not applicable
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
nm	nanometer
NSTISSI	National Security Telecommunications and Information Systems Security Instruction
OC	optical carrier
OSPDPR	Outside Plant Design and Performance Requirements
OSHA	Occupational Safety and Health Administration
OSP	outside plant
OTDR	Optical Time Domain Reflectometer

PBX	private branch exchange
PE	polyethylene
PET	protected entrance terminal
PIN	positive intrinsic negative
PM	project manager
PMD	polarization mode dispersion
PM DCASS	Project Manager, Defense Communications and Army Switched Systems
PMO	Provost Marshal's Office
POTS	plain old telephone service
ps	picosecond
PSI	pounds per square inch
PVC	Polyvinyl Chloride
QA	quality assurance
QC	quality control
RMC	rigid metal conduit
RSC	rigid steel conduit
RSU	remote switching unit
RT	remote terminal
RUS	Rural Utilities Service
SC	subscriber connector
SHDSL	single-line high-bit-rate digital subscriber line
SNMP	Simple Network Management Protocol
SONET	Synchronous Optical Network
SOR	Statement of Requirements
SOW	Statement of Work
SSR	Site Survey Report
ST	smart terminal
STS	synchronous transport signal
TE&CM	Telephone Engineering and Construction Manual
TPOC	technical point of contact
TTC	Trenchless Technology Center
UL	Underwriters Laboratory
UPSR	unidirectional path switched ring
UPS	uninterruptible power supply
URL	Universal Resource Locator
USAISEC	U.S. Army Information Systems Engineering Command

v	volts
VAC	volts alternating current
VDC	volts direct current
VDE	Verband der Elektrotechnik Elektronik Informationstechnik
VPC	volts per cell
W2K	Windows 2000
WATS	wide area telephone service
WLAN	wireless local area network
WiMAX	Worldwide Interoperability for Microwave Access
yd^3	cubic yard