UFC 3-580-01
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UNIFIED FACILITIES CRITERIA (UFC)

INFORMATION AND COMMUNICATIONS TECHNOLOGY INFRASTRUCTURE PLANNING AND DESIGN

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INFORMATION AND COMMUNICATIONS TECHNOLOGY INFRASTRUCTURE PLANNING AND DESIGN

U.S. ARMY CORPS OF ENGINEERS (Preparing Activity)

NAVAL FACILITIES ENGINEERING SYSTEMS COMMAND

AIR FORCE CIVIL ENGINEER CENTER

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location

This UFC supersedes MIL-HDBK-1012/3, dated 31 May 1996 and UFC 3-580-01, dated 1 June 2016.

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FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States, its territories, and possessions is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Military Department's responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Systems Command (NAVFAC), and Air Force Civil Engineer Center (AFCEC) are responsible for administration of the UFC system. Technical content of UFC is the responsibility of the cognizant DoD working group. Defense Agencies should contact the respective DoD Working Group for document interpretation and improvements. Recommended changes with supporting rationale may be sent to the respective DoD working group by submitting a Criteria Change Request (CCR) via the Internet site listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide website https://www.wbdg.org/ffc/dod.

Refer to UFC 1-200-01, *DoD Building Code*, for implementation of new issuances on projects.

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TABLE OF CONTENTS

FIGURES

TABLES

CHAPTER 1 INTRODUCTION

1-1 PURPOSE AND SCOPE.

This UFC provides design criteria for telecommunications spaces, pathways, cabling, and interconnecting components necessary to support the infrastructure for voice, data, video, smart buildings, and Internet of Things (IoT) systems. It does not address the design and specifics of the technologies that employ information communications technology infrastructure. "Video systems" includes the necessary infrastructure for closed circuit television (CCTV); community antenna television (CATV), commonly referred to as cable TV; video teleconferencing (VTC); and video walls.

1-2 REISSUES AND CANCELS.

This UFC reissues and cancels UFC 3-580-01, 1 June 2016; MIL-HDBK-1012/3, dated 31 May 1996; and Army publications *Installation Information Infrastructure Architecture (I3A)*," dated February 2010, "*Installation Information Infrastructure Architecture (I3A) for Outside Plant Only*," dated November 2017, "*Outside Plant Design and Performance Requirements (OSPDPR)*," dated February 2009, "*OSPDPR Addendum 1 – Core and Distribution Fiber Sizing Criteria for Installation Campus Area Network Design and Implementation*," dated September 2014.

1-3 APPLICABILITY.

This UFC applies to planning, design, construction, sustainment, restoration, and modernization of DoD-owned facilities. It applies to all methods of project delivery and levels of construction as defined by UFC 1-200-01, Section 1-3.

1-4 GENERAL BUILDING REQUIREMENTS.

Comply with UFC 1-200-01. UFC 1-200-01 provides applicable model building codes and government-unique criteria for typical design disciplines and building systems, as well as accessibility, antiterrorism, security, high performance and sustainability, and safety requirements. Use this UFC in addition to UFC 1-200-01 and the UFCs and government criteria referenced within.

1-5 CYBERSECURITY.

All facility-related control systems (including systems separate from a utility monitoring and control system) must be planned, designed, acquired, executed, and maintained in accordance with UFC 4-010-06, and as required by individual Service implementation policy.

1-6 Governing Criteria for Electrical Systems.

UFC 3-501-01 provides the criteria for electrical systems, delineates among electrical-related UFCs, and refers to UFC 3-520-01 for interior electrical system requirements.

1-7 Modernization Within Existing Facilities.

Modernization of information communications technology systems within existing facilities solely for the purpose of meeting design criteria in this UFC is not required.

1-8 Activity Specific Telecommunications Managers.

Throughout this UFC, the term “Telecommunications Manager” refers to:

- Army – the Network Enterprise Center (NEC) or the Information Officer (G6, S6, J6)
- Navy – a group of individuals with responsibilities as shown in Figure 6-1.
- Marine Corps – G6.
- Air Force – A6.

1-9 GLOSSARY.

Appendix B contains acronyms, abbreviations, and terms.

1-10 References.

Appendix C contains a list of references used in this UFC. Publication dates are not included; the most recent issuances apply unless otherwise specified.

CHAPTER 2 DESIGN REQUIREMENTS

2-1 General Guidance.

Design information communications technology infrastructure to meet the needs of the activity and supporting facilities in accordance with this UFC. Final drawings and specifications for design-bid-build and design-build projects must be stamped by a Building Industry Consulting Service, International (BICSI), Inc., Registered Communications Distribution Designer (RCDD).

Because construction phases may be concurrent with design in design-build projects, and because multiple phases of construction may be approved, the final documents for each construction phase must be stamped when approved.

2-1.1 U.S. Government- (USG-) Designed Projects.

On USG-designed projects (in-house design), the USG designer must:

- Obtain the approval of the Service-appointed information communications technology agent at the beginning of design in accordance with regulations, policies, memorandums, and guidance.
- Ensure that the bid documents require an RCDD stamp on the contractor's telecommunications shop drawings submitted for approval.
- Ensure final drawings and specifications for design-bid-build and design-build projects have been reviewed and approved by a BICSI RCDD.

2-1.2 Small Scale Projects.

Small scale projects limited to adding work area outlets from existing telecommunications rooms do not require an RCDD stamp, provided the work is being accomplished under the technical authority of an RCDD or the USG Information Communications Technology Manager.

2-1.3 Design Elements.

The complexity of Information and Communications Technology (ICT) design requires that the Designer of Record (DOR) engage early to achieve successful outcomes. Tables 2-1 and 2-2 list expected submissions and when they are due in the process. These timeframes may be adjusted for fast-tracked or other delivery mechanisms to align with design processes.

Table 2-1 ICT Design Submittal Schedule

DESIGN LEVEL	0% Charrette	30% Design Development	60% Interim Design	90% Final Design Submittal	100% Corrected Final Design
	SD	DD	ID	FD	CFD
Drawings					
T0		$T0^{DD}$	$T0^{ID}$	$T0^{FD}$	$T0^{CFD}$
T1			$T1^{ID}$	$T1^{FD}$	$T1^{CFD}$
T2			$T2^{ID}$	$T2^{FD}$	$T2^{CFD}$
T3		$T3^{DD}$	$T3^{ID}$	$T3^{FD}$	$T3^{CFD}$
T4				$T4^{FD}$	$T4^{CFD}$
T5 T6				$T5^{FD}$	$T5^{CFD}$
Specifications					
S			S^{ID}	S^{FD}	S^{CFD}
Design Analysis					
DA	DA^{SD}	DA^{DD}	DA^{ID}	DA^{FD}	DA^{CFD}

Table 2-2 Required Drawings

DRAWINGS	DESCRIPTION*
T0	Site information
$T0^{DD}$	Site drawing should show existing ICT utilities at DD
$T0^{ID}$	Routing and quantities of new ICT utilities
$T0^{FD}$	Final site ICT drawings
T1	Buildings
$T1^{ID}$	Show all workstation outlets, service oulets, and ICT elements on floor plans
$T1^{FD}$	Complete ICT design
$T1^{CFD}$	Incorporate approved comments generated during the final review into final design
T2	Serving zone information
$T2^{ID}$	Show all serving zones and ICT spaces with primary and secondary pathways, as applicable
$T2^{FD}$	All pathways and drop locations and other elements are complete
$T2^{CFD}$	Incorporate the approved comments generated during the final review into the final design
T3	Telecommunications rooms

DRAWINGS	DESCRIPTION*
$T3^{DD}$	The floor plan needs to be locked in early. The ICT designer must perform work early and up-front preparing T3 telecommunication rooms plan views to ensure that adequate space is allocated for the equipment, including working clearances for the life cycle of the facility.
$T3^{ID}$	Show all equipment including Facility Related Control System (FRCS) and other OT along with IT.
$T3^{FD}$	Complete ICT design.
$T3^{CFD}$	Incorporate approved comments generated during the final review into the final design.
T4	Details
$T4^{FD}$	All details complete, including labeling schemes, rack elevations, work station outlet details, wireless access points (WAP) mounting.
$T4^{CFD}$	Incorporate approved comments generated during final review into final design.
T5	Schedules
$T5^{FD}$	All schedules complete and cable plant management including cut-overs complete
$T5^{CFD}$	Incorporate approved comments generated during final review into final design
T6	Network diagrams, riser diagrams, and boundary diagrams
$T6^{DD}$	The floor plan needs to be locked in early. The ICT designer must perform work early and up-front preparing T3 telecommunication rooms plan views to ensure that adequate space is allocated for the equipment, including working clearances for the life cycle of the facility.
$T6^{ID}$	Show all equipment including Facility Related Control System (FRCS) and other OT along with IT.
$T6^{FD}$	Complete ICT design.
$T6^{CFD}$	Incorporate approved comments generated during the final review into the final design.
S^{ID}	List all applicable specifications and include even if unedited.
S^{FD}	All ICT specifications complete
S^{CFD}	Incorporate approved comments generated during final review into final design.
DA^{SD}	All ICT systems identified in the design scope should be listed with points of contact (POC) for systems.
DA^{DD}	A subsection for each ICT system and all design criteria should be listed.

DRAWINGS	DESCRIPTION*
DA^{ID}	The design analysis must be an entirely updated analysis (not amendments to 30% submittal) to permit verification that the design complies with the criteria furnished, the approved 30% design phase, and approved review comments. Information required at the 30% design phase must be included with more detail.
DA^{FD}	ICT sections of design analysis complete
DA^{CFD}	Incorporate approved comments generated during final review into final design.

* Refer to TIA 606 for additional details.

2-2 SECURE SPACE INFRASTRUCTURE.

Secure spaces include classified networks such as Secret Internet Protocol Router Network (SIPRNet), Joint Worldwide Intelligence Communications System (JWICS), or National Security Agency Intranet (NSANet). These networks process National Security Information (NSI) and have unique requirements.

2-2.1 RED/BLACK Telecommunications Systems.

All equipment, wirelines, components, and systems that process NSI are considered RED. Equipment, wirelines, components, and systems that process encrypted NSI and non-NSI are considered BLACK. BLACK lines and other electrically conductive materials that egress the inspectable space are potential carriers of compromising emanations (CE) that can inadvertently couple to the RED lines. Various signal line isolation techniques such as separation and filtering are used to protect the signal line, the distribution system, or other fortuitous conductors from conducting compromising signals beyond secure areas.

Apply fundamental RED/BLACK separation in accordance with Committee on National Security Systems Advisory Memorandum (CNSSAM) 1-13 to prevent inadvertent transmission of classified data over telephone lines, power lines, signal lines, and electrical components, circuits, and communication media. Application of RED/BLACK separation establishes areas where equipment that processes classified information (RED) is isolated from areas where equipment processing unclassified (BLACK) is located.

2-2.2 Telecommunications Space.

Account for the space required for equipment rooms and telecommunications rooms and ensure it is adequate to meet separation requirements before floor plans are locked in. The minimum sizing in this UFC is presented with a single black network and does not account for RED networks and the separations between the racks or cabinets in the space. A telecommunications space that contains equipment for multiple networks such as SIPRNet, JWICS, and NIPRNet all requiring RED/BLACK separation is considered as substantial information technology (IT) electronics which would require use of an equipment room.

2-2.3 Telecommunication Cabling System.

Cabling, patch panels, connector blocks, work area outlets, and cable connectors must be color-coded to distinguish their classification level. If color-coding is not possible, cabling must be clearly marked to indicate classification level. Provide detail sufficient for the security officer to submit and obtain approval from the certified TEMPEST technical authority. Design submittals must document RED/BLACK and checklist items from Intelligence Community Directive (ICD) Tech Spec, including the TEMPEST checklist items specific to telecommunications systems.

2-2.4 Protected Distribution Systems.

Use a protected signal distribution system (PDS) to protect unencrypted NSI that enters an area of lower classification, unclassified area, or uncontrolled (public) area. The PDS must comply with Committee on National Security Systems Instruction (CNSSI) No. 7003. Mount standard PDSs 1 inch (25 millimeters) from walls and other objects. To prevent obfuscating repairs made to the raceway, paint must not be field-applied. With prior approval from the Telecommunications Manager, galvanized rigid steel conduit (GRC) or electrical metallic tubing (EMT) may be used in addition to other approved surface mount raceways. Compression-type fittings are required with black epoxy glue applied to prevent tampering and as an aid to visual inspection. GRC compression or threaded fittings may be used with epoxy.

Due to inspection requirements, avoid using PDS whenever possible. To avoid PDS, keep cabling that transmits unencrypted NSI within the protected perimeter.

2-2.5 Alarmed Carrier.

An alarmed carrier may be used as an alternative to a physical PDS. Refer to CNSSI 7003.

2-2.6 Sensitive Compartmented Information Facility (SCIF) and Special Access Program Facility (SAPF).

Refer to UFC 4-010-05 and CNSSAM 1-13 RED/BLACK installation guidance.

2-2.7 Stand Alone SIPRNet Terminal Space.

Paragraphs 2-2.7.1 through 2-2.7.3 describe where a SIPRNet workstation outlet is required in a facility that lacks secure telecommunications spaces.

2-2.7.1 Pathways.

Provide PDS between the telecommunications enclosure and the lockable workstation outlet. Maintain a 6-inch (150-millimeter) separation between the workstation outlet and any other workstation outlet.

2-2.7.2 Telecommunication Equipment Enclosure.

When secure telecommunications spaces in a facility build-out are not equipped, specify a GSA-approved information processing system (IPS) container to house electronics that will permit a black-to-red transition. The container door must be specified and equipped with a Federal Specification FF-L-2740 lock.

2-2.7.3 Workstation Outlet Enclosure.

Enclosures must not have knockouts and must be metallic 16 gauge or greater. Hinges must be continuous and non-removable. Enclosures must not be field-painted, but may have factory-baked enamel or be galvanized. Enclosures must be continuously sealed with epoxy or welding of all joints except the hinged opening. Non-removable hasps must be equipped that will accept a lock meeting FF-P-110-J. Enclosures for workstation outlets must be GSA-approved.

2-3 SYSTEM DESIGN REQUIREMENTS.

Provide a complete, standards-based, flexible information communications technology design, including telecommunications spaces, pathways, outlets, connectors, cabling, grounding, bonding, and static protection in accordance with paragraphs 2-3.1 through 2-4.

2-3.1 Telecommunications Spaces.

Provide telecommunications spaces in accordance with Telecommunications Industry Association (TIA)-569. Refer to Figure 2-1.

Note: This UFC uses commercial terminology for spaces in accordance with the TIA-569-E errata sheet (e.g., telecommunications room, equipment room versus distributor room A and B, and telecommunications enclosure versus distributor enclosure).

2-3.1.1 Types of Telecommunications Spaces.

a. Telecommunications Entrance Facility. An entrance facility (EF) is the space housing the point of entrance of the information communications technology service. The EF is also the space where the inter-building backbone and intra-building backbone facilities join. Telecommunication-related antenna entrances and electronic equipment may be located in the EF. The demarcation point between the outside plant (OSP) cabling and the inside plant distribution cabling is the protected entrance terminal (PET). See Chapters 2 and 3 for PET requirements.

The DOR should coordinate with the Telecommunications Manager for additional physical security requirements inside the EF including, but not limited to, colocation cabinet(s) if required for commercial or other carriers.

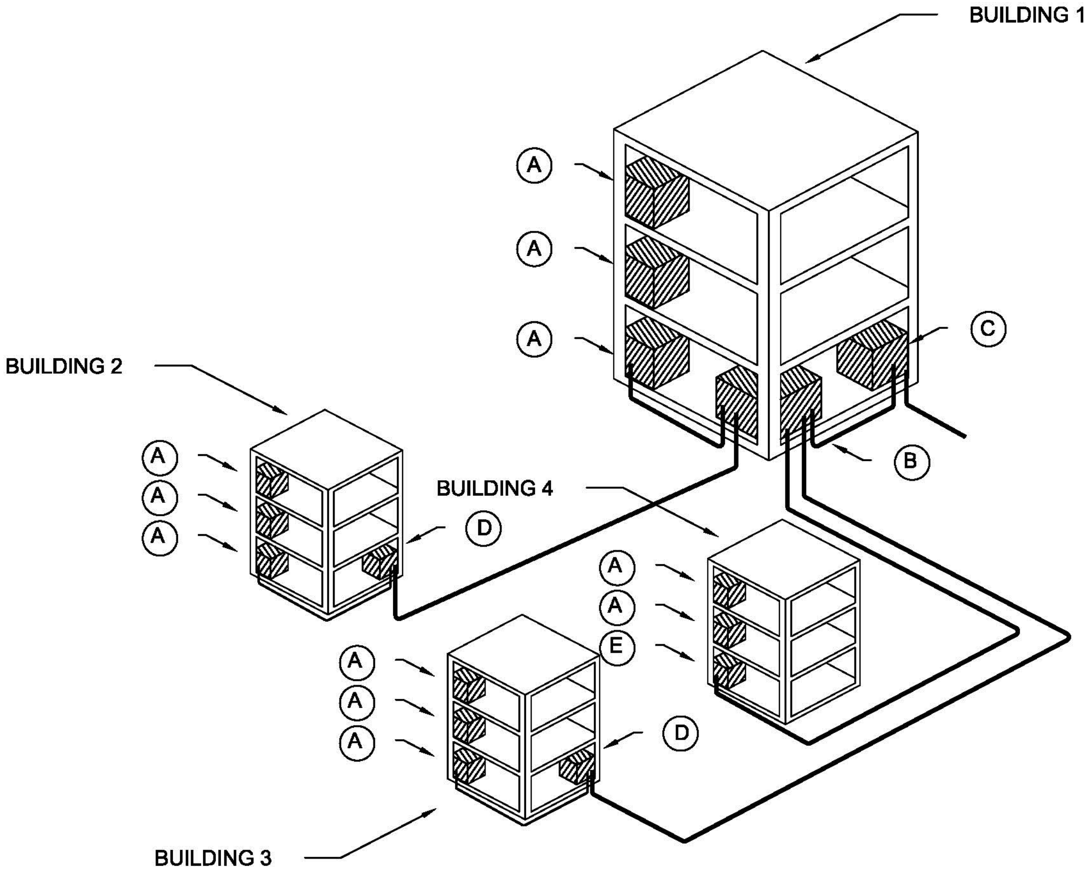
b. Telecommunications Room. A telecommunications room (TR) is an architectural space designed to contain information communications technology equipment, cable terminations, and cross-connect cabling. It contains the information communications technology equipment for connecting the horizontal cabling with the backbone cabling system. The TR may also function as the telecommunications EF.

c. Equipment Room. An equipment room (ER) is an environmentally-controlled, centralized space for information communications technology equipment that typically houses a main or intermediate cross-connect. Any or all the functions of a TR or EF may be provided by an equipment room.

d. Telecommunications Enclosure. A telecommunications enclosure (TE) is a case or housing for telecommunications equipment, cable terminations, and cross-connect cabling.

Although TEs serve much like TRs, a TE must not replace a TR. TEs may be considered for buildings with fewer than 10 occupants when approved by the COR for contract designs or the Government design lead for in-house designs. The TE is referred to as a distributor enclosure in TIA-569. TEs must meet TIA-569's requirements for distributor enclosures.

Figure 2-1 Telecommunications Spaces and Cabling



LEGEND	
TR	TELECOMMUNICATIONS ROOM
ER	EQUIPMENT ROOM
EF	ENTRANCE FACILITY
HC	HORIZONTAL CROSSCONNECT
IC	INTERMEDIATE CROSSCONNECT
MC	MAIN CROSSCONNECT
FD	FLOOR DISTRIBUTOR
BD	BUILDING DISTRIBUTOR
CD	CAMPUS DISTRIBUTOR

A	SPACE	CONTAINS	
(A)	TR	HC (FD)	DA
(B)	ER	MC (CD)	DC
(C)	EF		
(D)	ER	IC (BD)	DB
(E)	EF	IC/HC(BD/FD)	DA/DB

2-3.1.2 Architectural Considerations.

2-3.1.2.1 Location and Access.

Locate telecommunications spaces so that the maximum cable length from the patch panel through the structured cabling system to the furthest outlet does not exceed 295 feet (90 meters). Telecommunications spaces must be dedicated spaces not shared with other non-information communications technology functions (electrical rooms, mechanical rooms, plumbing). Avoid locations that are restricted by building components that may limit expansion, such as elevators, outside walls, or other fixed building walls. Spaces must be capable of expanding on no less than two sides. Evaluate locations for risk to critical infrastructure (water, dust, electromagnetic impulse (EMI) influence). Locate the telecommunications space away from sources of electromagnetic interference or design the space to mitigate the effects of this interference. Give special attention to electrical power supply transformers, motors and generators, x-ray equipment, and radio or radar transmitters. Locate spaces in an accessible area of the building (e.g., common hallway), but limit access to personnel having an information communications technology requirement or mission. The space must be accessible for delivery of equipment such as network switches, equipment racks, and cabinets.

In renovation projects, avoid rooms containing transformers, air handling units, and similar equipment. If shared facilities cannot be avoided, comply with TIA-569.

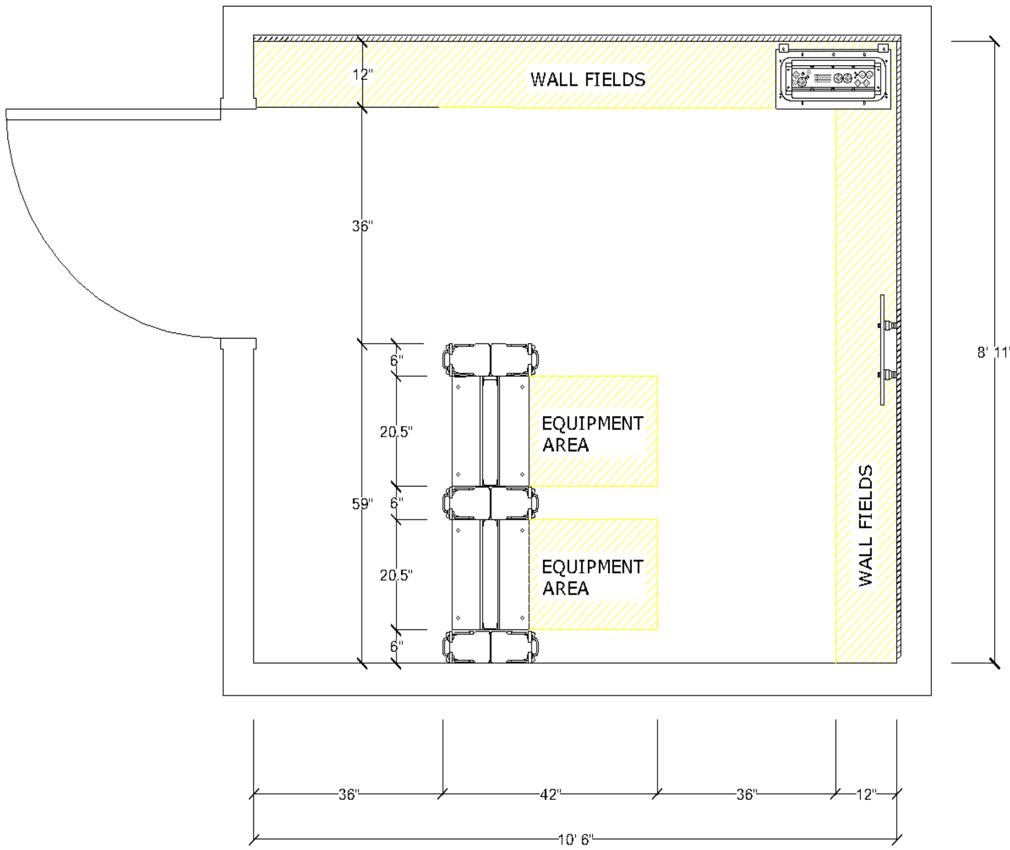
2-3.1.2.2 Telecommunication Spaces Sizing and Quantity.

a. Space for working clearances is critical to allow maintenance activities including moves and changes.

b. Size each TR in accordance with ANSI/TIA-568, with the exception that the minimum TR size for DoD buildings is 10 feet, 6 inches by 9 feet (3.2 meters by 2.7 meters) in buildings larger than 5,000 square feet (464.5 square meters) (Figure 2-2). This will allow a minimum of one spare rack for telecommunication spaces that can be served by one rack to comply with paragraph 2-3.1.5.3 and allows space for equipment mounted on walls.

Adjust the dimensions if vertical cable management for cable longer than shown in Figure 2-2 is required.

Figure 2-2 Minimum Telecommunications Spaces Sizing



c. As best practice, size TRs to approximately 1.1 percent of the area it serves. For example, a 10,000 square foot (929 square meter) area should be served by a minimum of one 10 foot-by-11 foot (3 meter-by-3.4 meter) TR. Divide large floor areas into “serving areas” with TRs for each serving area. Serving area must be no larger than 10,000 square feet (929 square meters) and must not serve more than 20,000 square feet (1,858 square meters). When a TR is designed to serve spaces larger than 10,000 square feet, verify the size of the TR is adequate. Allow for code-required clearances in space allocations.

d. Heating, ventilation, and air conditioning (HVAC) requirements may be substantially affected if additional systems are required in the TR. Consult with the architectural designer or facilities engineer when additional systems requirements (audio visual systems, servers, disk storage arrays) are integrated into the TR.

e. Consider using an ER for areas that exceed 10,000 square feet or for buildings that house substantial IT electronics.

Note: One TR may be adequate for multi-story buildings or in unique facilities. Refer to paragraph 2-3.1.2.5.

f. Ensure adequate space in TRs to accommodate tenant-owned data and information communications technology systems, including FRCS. Support equipment requirements in tenant-installed freestanding cabinets or racks. Total TR space as a percentage of the building's area must be scaled upward to reflect any increase in horizontal drops to each workspace in buildings with more than the standard number. Examples may include command and control facilities or health care facilities.

2-3.1.2.3 Floors, Walls, and Ceilings.

For floors, walls, and ceilings in telecommunications spaces, meet the requirements in TIA-569. Do not install suspended ceilings in telecommunications spaces.

2-3.1.2.4 Doors and Windows.

Exterior and interior doors must satisfy fire rating requirements for TRs in TIA-569 and National Fire Protection Association (NFPA) 101®. For security reasons, exterior windows or architectural window equivalents are not permitted

2-3.1.2.5 Multi-Story Buildings and Unique Facilities.

Provide a minimum of one TR per floor. Provide additional rooms when the floor area is greater than 20,000 square feet and/or the total cable distance to the outlet is over 295 feet (90 meters). Serve all information communications technology outlets from the TR located on that floor. Vertically align TRs on successive floors to allow the risers to align on the same walls. In the case of small and unique facilities, a single TR may be adequate for the entire facility. These facilities include, but are not limited to, air traffic control towers, warehouses, firing ranges, and range and weapons towers.

2-3.1.3 Utility Considerations.

2-3.1.3.1 Lighting.

Design lighting for telecommunications spaces in accordance with UFC 3-530-01. Illumination over aisles should coordinate with overhead runway systems.

2-3.1.3.2 Power.

Provide a dedicated electrical branch circuit panel board for each TR meeting the following minimum requirements: 120/208 volt (V), 3-phase or 120/240V, 1-phase, 24- (or 20- for 1-phase) space panel with a minimum 100 ampere (A) bus rated capacity. Feed loads within the TR from this dedicated TR panel. Loads must include, but are not limited to, convenience receptacles, dedicated rack or cabinet receptacles, and HVAC systems (including exterior units for split systems). Provide 125V, 20A duplex convenience receptacles at 6-foot (1.8-meter) intervals on-center around perimeter walls.

Unless otherwise specified by the Telecommunications Manager, provide a minimum of one receptacle at each rack. To minimize accidental shutoff, equip power strips with indicator lights, but no integral on/off switch. Provide matching (National Electrical

Manufacturers Association (NEMA) configured) twist-lock type receptacles fed from dedicated circuits in the TR panel or from a busway to power each power strip. Install twist-lock receptacles above the rack or cabinet mounted to an information communications technology cable tray. As some rack- or cabinet-mounted equipment may require more power, consult with the local information communications technology group having jurisdiction to determine exact electrical power requirements for each TR.

2-3.1.3.3 Heating, Ventilation, and Air Conditioning.

Design telecommunications spaces to meet HVAC requirements of TIA-569, including the Class B requirements for temperature and humidity as outlined in American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) *Thermal Guidelines for Data Processing Environments*. Class B space includes only temperature control. When the IT equipment (ITE) load includes enterprise servers, volume servers, storage products, and other computing environment, the space may be categorized as A4 or A3. TRs will be Class B. ERs may be Class B or Class A4, depending upon the user’s equipment load. Work with the system owner to understand the environmental needs and coordinate them with the full design team.

2-3.1.3.4 Room Climate Control.

a. Provide each TR with its own independent thermostat for climate control, capable of supporting year-round ambient temperature control (24 hours per day, 365 days per year) to protect all installed electronic equipment as defined in TIA-569. The mechanical system designer of record must determine the type of system required to meet the environmental condition requirements for all telecommunications spaces. Data centers may require a narrower environmental envelope to safeguard equipment function. Do not include heating and cooling systems within TRs on building time clocks or other temperature setback mechanisms. Provide rooms with positive atmospheric pressure to minimize dust when required by system owners or equipment manufacturers.

b. Design cabinets and rows to avoid recirculation of exhaust air into equipment intakes. Specify blanking panels and baffles as needed to mitigate intra-cabinet circulation. Equipment should be arranged into hot and cold aisles when more advanced schemes of cooling are not used.

c. Do not use electrical name plate data for cooling requirement calculations. Manufacturer heat load data by equipment is best for use in calculating cooling requirements but is not always available. The mechanical designer must determine the amount of cooling required, but will need to collaborate with the telecom designer to understand requirements.

d. Design cooling load capacity to include growth capabilities for IT refresh planning in accordance with ASHRAE 90454. For calculated loads less than one ton (12,000 British thermal units per hour (BTU/hr)), provide a single air conditioning (A/C) unit with space and power capacity to install another identical unit for future load growth. For loads greater than one ton, install two identical units sized for 50% to 60% of the load each, and provide space and power capacity for an additional identically-sized unit for future load growth. For loads greater than 10 tons (120,000 BTU/hr), and where redundant uninterruptable power systems (UPS) have been installed in the telecommunications space, provide more than two A/C units to meet the N+1 redundancy criteria, where N is the number of A/C units required to meet the load (not less than 2), and 1 is the identically-sized redundant spare. In addition to the one redundant spare A/C unit, provide space and power capacity for one additional identically-sized A/C unit for future load growth. Other redundancy requirements may be required by the mission. Ensure IT, power, and mechanical cooling requirements are aligned with the mission.

e. Utility piping serving telecommunications spaces must not be routed over communications racks or cabinets or electrical panels. Where routing over sensitive areas cannot be avoided, provide all wet and drainage piping with special protection, such as double-wall containment piping or drip pans with leak detection to protect the space below from leakage and/or condensation.

2-3.1.4 Room Contaminants.

Do not install information systems equipment in spaces where moisture, liquid or gaseous spillage, or other contaminants may be present, as defined in TIA-569. Do not design spaces that will have a wet wall that can provide ingress of liquids or potentially require maintenance from inside of the telecommunications space for unrelated utilities.

2-3.1.5 Space Components.

For all ICT components, use manufacturer’s standard catalog products that conform to the latest published industry and technical society standards at the date of contract award. Do not use shop- or field-fabricated components that are not manufacturer's standard catalog products or that do not conform to the industry and technical society standards.

2-3.1.5.1 Plywood Backboards.

Provide backboards in accordance with TIA-569. Fire retardant treated wood must comply with International Building Code, Section 2303.2. Backboards must be fire-retardant-treated wood, bearing the manufacturer’s stamp. Backboards are not required to be painted unless requested by the Information Communications Technology Manager for illumination reflectance. They must display at least one fire-rated stamp after wall-mounted equipment is installed and they are painted. Cover a minimum of two adjacent walls with backboards. Allow 1 foot (305 millimeters) of depth space for wall-mounted equipment when calculating room sizes. If equipment with a known depth greater than 1 foot will be used, also allow for that space and required clearance. When renovating an existing TR that does not have adequate space, size the backboard as large as possible to accommodate wall-mounted equipment.

2-3.1.5.2 Protected Entrance Terminals.

TIA-758 identifies two types of building entrance terminals (BET) -- protected and non-protected. Provide protected entrance terminals (PET) in accordance with TIA-758. Equip PETs with modules to protect the inside plant cabling and equipment from power surges. Furnish solid state or gas tube modules adequate for all used pairs plus 25%, but not to exceed the total pair count. Provide 110-type insulation displacement connector (IDC) terminal blocks or cable stubs. See paragraph 2-4 for grounding requirements. Refer to Chapter 3 for OSP requirements.

2-3.1.5.3 Equipment Racks.

Provide 19-inch (475-millimeter) floor-mounted equipment racks. A minimum of 36 inches' (900 millimeters') space, both in front and behind the rack measured from the equipment, and a minimum side clearance of 36 inches on at least one end of the rack or row of adjacent racks is required. Allow a front-to rear-space of 42 inches (1067 millimeters) to accommodate equipment. Coordinate with the Information Communications Technology Manager to determine the space and weight requirements for the USG-provided active equipment. A four-post rack may be required to support equipment due to weight or mounting requirements. Provide 25% spare rack unit capacity within each rack used. Provide one spare rack for every four used racks, with a minimum of one spare rack per telecommunication space.

In existing facilities with narrow or crowded telecommunication spaces, equipment racks may be wall-mounted with the approval of the Information Communications Technology Manager. Workspace around the cabinet/rack is still required even if the cabinet is mounted 6.5 feet (2 meters) off the floor. Refer to Figure 2-3.

2-3.1.5.4 Equipment Cabinets.

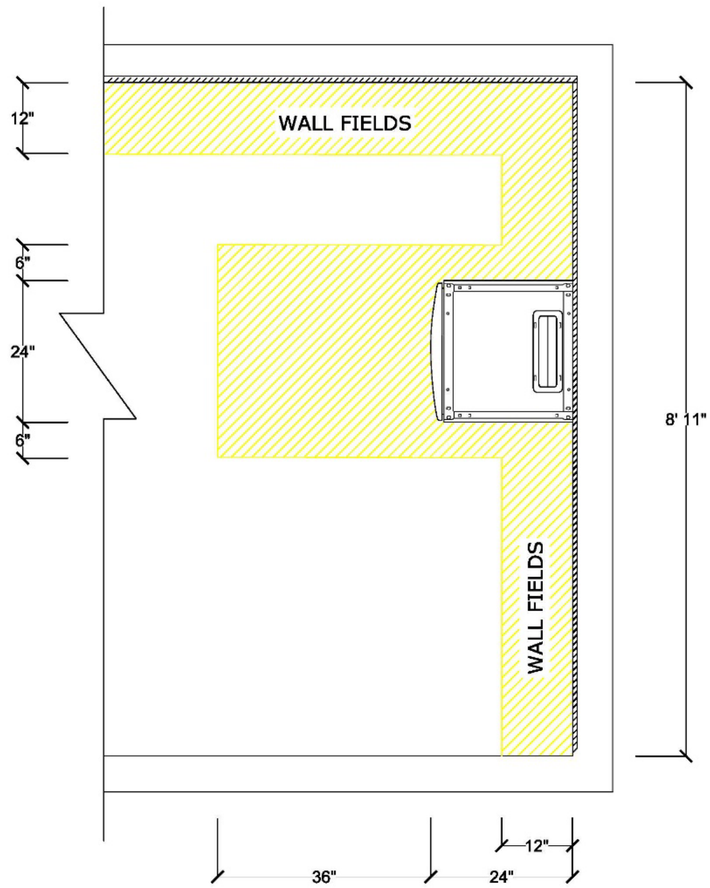
Provide equipment cabinets in lieu of racks where:

- identified by Service-specific chapters in this UFC.
- required by the Information Communications Technology Manager.
- physical security is required, such as to mount secure or mission critical equipment.
- separately controlled access is desired (when multiple systems are collocated within the room).

a. Provide a minimum 24 inch- (600 millimeter-) wide cabinets with cooling fans (when required) and internal rails to support 19-inch (475-millimeter) equipment. Locate cabinets in rows with front and rear clearance. A minimum space of 36 inches (900 millimeters), both in front and behind the cabinet, and a minimum side clearance of 24 inches (600 millimeters) on at least one end of the cabinet or row of adjacent cabinets is required. When an aisle is against a wall, cabinets should not exceed eight in a row.

b. Design cabinets with 63% mesh doors with blanks and baffling to ensure front-to-rear air flow and avoid intra-cabinet air circulation, unless another cooling method is designed. In instances where other air flow is needed, use manufacturer-approved penetrations and sealing to maintain airflow. For hot and cold aisles, use an airflow scheme engineered for the solution.

Figure 2-3 Wall Mounted or Floor Mounted Cabinet Clearance



c. Coordinate with the Information Communications Technology Manager to determine space requirements for the USG-provided active equipment. Provide 25% spare capacity within each cabinet used. Provide one spare cabinet for every four cabinets used, with a minimum of one spare cabinet per telecommunication space.

d. In existing facilities with narrow or crowded telecommunication spaces, equipment cabinets may be wall-mounted with the approval of the Information Communications Technology Manager. FRCS may require wall-mounted cabinets. Where space is limited and clearances are affected, use swing-out cabinets. See Figure 2-3.

2-3.1.6 Horizontal and Vertical Cable Management.

Provide horizontal cable management panels above and below each patch panel. The required ratio of horizontal cable management to patch panels is 1:1. Provide vertical cable management between racks and at the end of racks when required to protect, manage, and organize cables. Vertical cable management panels must be a minimum of 6 inches (150 millimeters) wide, and sized based on total anticipated cable plus 50%. Allow space against the wall for operation of vertical management covers.

2-3.1.7 Ladder and Wire Cable Tray.

Use ladder-type cable trays in telecommunication spaces to provide distribution between the plywood backboard, equipment racks, backbone conduits, and the distribution cable tray. Bond all metallic cable tray sections and bond the cable tray system to the primary bonding busbar (PBB) or secondary bonding busbar (SBB).

2-3.1.8 Copper Pair Patch Panels.

For patch panels, use 8-position, 8-contact (8P8C) modular jacks with rear-mounted 110-type IDC terminations, category rated for the copper cabling being installed, and arrange in rows or columns on 19-inch (475-millimeter) rack-mounted panels. For small projects (fewer than ten users), 19-inch TIA category-qualified wall mounted block or backboard patch panels may be used. Provide T568A jack pin/pair configuration per ANSI/TIA-568. T568B jack pin/pair configuration may be used only if required to maintain uniformity in an existing facility. Provide modular jacks that conform to the requirements of ANSI/TIA-568, rated for use with the installed cable plant. Install unshielded twisted pair (UTP) patch panels in the same rack or in the rack immediately adjacent to the local area network (LAN) equipment to minimize patch cord lengths. Provide a minimum spare capacity of 25 percent.

2-3.1.9 Fiber Optic Patch Panels.

Use patch panel connectors and couplers of the same type and configuration as used elsewhere in the system. Unless otherwise directed, use duplex lucent connectors (LC) or keyed LC connectors on 19-inch rack-mounted panels to support legacy installations. Provide a 3-foot (0.9-meter) slack loop of fiber within each panel and include strain relief for cables within the panel. Provide proper termination, splice storage, routing, radius limiting, cable fastening, strand storage, and cross-connection in all patch panels. Install fiber optic patch panels in the same rack or in the rack immediately adjacent to the LAN equipment to minimize patch cord lengths. Provide a minimum spare capacity of 25 percent.

Consider multi-fiber termination push-on (MTP®) factory-terminated fiber optic systems using cassettes to break out fibers. This has many advantages, including factory testing, shorter installation times, future-proofing connection types, and tap port options.

In existing facilities, other connector types may be used to match the current infrastructure with the approval of the Information Communications Technology Manager.

2-3.2 Telecommunications Pathways.

A pathway is a facility for placement of information communications technology cable.

2-3.2.1 Backbone Pathways.

Backbone pathways are structures that conceal, protect, support, and provide access to cables between telecommunications spaces. Examples of backbone pathways include conduit, sleeves, slots, cable trays, telecommunication spaces, and miscellaneous support facilities.

For intra-building backbone distribution, use a minimum of two 4-inch (100-millimeter) conduits between TRs located on the same floor, or a pathway that provides equivalent capacity (e.g., cable tray installed to support backbone and horizontal distribution).

In multistory buildings, use a minimum of three 4-inch conduits, sleeves, or an equivalently-sized slot between stacked TRs on successive floors in accordance with TIA-569. Design at least N+1 raceways to support moves, adds, and changes (MAC). Nationally Recognized Testing Laboratory (NRTL)-rated fire assembly is required for penetrations through telecommunication space walls.

2-3.2.2 Horizontal Pathways.

Horizontal pathways are structures that conceal, protect, support, and provide access to cables between the telecommunications spaces and the work area outlet. Examples of horizontal pathways include conduit, cable trays, ceiling distribution, access floors, and non-continuous cable supports (J-hooks).

There are many methods to distribute cable from the telecommunication space to the work area, and many buildings may require a combination of two or more types of pathway systems to meet all distribution needs. The DoD-required horizontal pathway is a ceiling distribution system employing a centralized cable tray system originating in the telecommunication space and continuing out into the serving areas. Use cable trays for horizontal distribution to the maximum extent possible (maximum horizontal distance: 50 feet (15,240 millimeters) in open face hangers). The remaining pathway to the work area outlet may be implemented in a variety of ways combining conduit, non-continuous cable supports, and stub-ups/outs.

2-3.2.2.1 Open Office Wiring.

Open office wiring refers to work space divided by modular furniture and partitions rather than fixed walls. The electrical designer, the architect, and the interior designer must coordinate layout of all furniture with electrical and information communications technology outlets during the design process. Typically, furniture is selected and ordered when construction is nearing completion; without proper coordination early in the design process, field interface problems will occur.

a. Systems Furniture. Use architectural columns and perimeter walls to the maximum extent possible for information communications technology distribution to systems furniture workstations. Where permitted, use utility columns in the absence of architectural columns or when systems furniture is located away from perimeter walls. Only if no other alternative exists, use under-floor conduits designed and installed in accordance with TIA-569. Include a spare conduit to under-floor outlet boxes for future expansion. Design systems furniture wiring connections in accordance with ANSI/TIA-568 and TIA-569.

Due to the uncertainty of final furniture type and layout, design wiring length for furniture outlets to the farthest point of each furniture group, plus 10 feet of extra wiring. If systems furniture has been selected and has pathways sufficient for pre-terminated cabling, consider consolidation points with factory patch cords.

b. Protection and Separation in Systems Furniture and Utility Columns. When systems furniture does not provide a metallic separation or have power in a metallic raceway, ensure separation between telecommunication and power wiring in the utility columns and systems furniture track in accordance with TIA-569 and NFPA 70®.

c. Horizontal Distribution in Small Facilities and Renovations. In new construction involving small, mixed-use (non-administrative) facilities or construction projects involving renovation of existing buildings, use of J-hooks, flexible cable trays, and alternative support systems specifically certified for Category 6A cable is permitted, but not desirable. In renovation projects where access to the walls for installation of conduit and outlet boxes is not possible, or where historical requirements prohibit alteration of the building structure, surface-mounted non-metallic raceway may be used.

2-3.2.3 Pathway Components.

2-3.2.3.1 Cable Trays.

Use solid bottom, slotted bottom, or welded wire cable trays to provide a centralized cable management/distribution system.

a. Use the cable tray for horizontal distribution to the maximum extent possible (80 percent to 90 percent of the horizontal cable length).

b. Design cable trays to accommodate an initial calculated fill ratio of 25 percent.

Note: This allows for future growth within the cable tray. Due to random placement of cables and space between the cables, a 25 percent fill ratio means that the tray is half filled.

c. Follow manufacturers' recommendations for weight, considering both tray capacity and cable loading capacities.

d. Maximum fill ratio of any cable tray is 50%.

e. Maximum fill depth of any cable tray is 6 inches (150 millimeters).

f. Do not use ladder cable trays for horizontal distribution outside of the TR or ER due to possible cable deformation when using large quantities of cable.

g. Maintain a minimum of 12 inches (300 millimeters) access headroom above a cable tray system or cable runway and 12 inches (300 millimeters) side access clearance on one side of the cable tray system or cable runway. Where this cannot be achieved, maintain an 8-inch (203-millimeter) clearance including seismic restraints.

h. Side and top encroachment distance may be less than 3 feet (914 millimeters) in a 20-foot (6096-millimeter) section of cable tray provided it does not prohibit access to raceways that feed into the tray. These encroachments must be approved by the AHJ with written consent by the Information Communications Technology Manager.

2-3.2.3.2 Conduit.

Design conduit systems in accordance with TIA-569. Install EMT conduit from the cable backbone distribution system, whether cable tray or enclosed duct, to each outlet, unless a conduit-less system is approved by the Information Communications Technology Manager. For standard outlets, use a minimum 1-inch (27-millimeter) EMT conduit. When cable tray or enclosed duct is not used, use individual conduits from the TR to each outlet. Coordinate conduit bend radius with cable bend radius. Arrange conduit entries at outlet and junction boxes so that cables passing through the box enter and exit at opposite sides of the box. Do not use flexible metal conduit for information communications technology wiring except when installing floor access boxes in a raised floor where the floor access box may be relocated within a specified service area. In this case, the length of the flexible metal conduit must not exceed 20 feet (6096 millimeters) for each run, per TIA-569.

Avoid using in-slab and below grade conduit systems for interior designs as these systems provide the least flexible horizontal distribution system. If an in-slab or below grade conduit system is used in the design, comply with NFPA 70® and use listed cables rated for wet locations. Do not use plenum or riser rated cable, gel-filled OSP, and unlisted cables in such an environment. Cables rated for a wet location typically have a larger outside diameter which may affect conduit fill rates and conduit sizing. Larger conduit sizing in the slab may affect the integrity of the structure. For in-floor conduit systems, provide home runs back to the TR serving that area. Serve all outlets from the TR located on that floor.

Use an optimal conduit fill ratio of 40 percent for conduit sizing. Do not exceed a fill ratio of 50 percent. Do not install more than four, four-pair cables in a 1-inch

(27-millimeter) conduit. Do not use conduit in a Family Housing project unless the project is a high-rise apartment building.

2-3.2.3.3 Non-continuous Cable Supports.

Non-continuous cable supports are not permitted in:

- place of the cable tray system or as the sole distribution system in place of home-run conduit. Design non-continuous cable supports to support the category rating of the cable.
- spaces that exceed 50 feet (15,240 millimeters) total length through a non-continuous cable support system.
- ceilings in which infection control protocol affects ceiling tile removal.
- spaces where cable must be protected.

When using non-continuous cable supports, comply with TIA-569. Supports must not exceed 20 cables or 50 percent of the fill capacity, whichever is less.

2-3.2.3.4 Pull and Splice Boxes.

A pull box is a housing located in a pathway run to facilitate placement of wire or cables. A splice box is a box located in a pathway run to house a cable splice. Place pull and splice boxes in conduit runs in accordance with TIA-569.

2-3.3 Telecommunications Cabling.

In accordance with ANSI/TIA-568, backbone and horizontal cabling is typically installed in a hierarchical star configuration. Provide alternative topology when required by the mission and approved by the technical authority. Paragraph 2-3.1.1 pertains to copper and fiber optic backbone and horizontal cabling. Cable to support CCTV and CATV is addressed in paragraphs 2-3.5.1 and 2-3.5.2.

2-3.3.1 Backbone Cabling.

Paragraphs 2-3.3.1.1 and 2-3.3.1.2 pertain to copper and fiber optic intra-building backbone cable. Use no more than two hierarchical levels of cross-connects (main and intermediate) for the intra-building backbone. Use copper backbone cable only for voice circuits. Use fiber optic cable for data backbone circuits.

2-3.3.1.1 Copper.

Comply with the following:

- Use multi-pair voice backbone cable that and satisfies requirements of ANSI/TIA-568 for riser or plenum-rated UTP cable.
- Use solid untinned copper, 24 American Wire Gauge (AWG) conductors.

- Coordinate the copper backbone design with the Information Communications Technology Manager to minimize the amount of copper used.
- Use minimal copper backbone to support traditional two-wire phones and legacy systems as the transition to an all-fiber backbone occurs.
- For facilities that will use unified communications (voice, video, and data over Internet Protocol (IP)), use a minimum 25-pair copper backbone to each TR. Provide additional cable counts to support actual legacy system requirements.
- For facilities using legacy systems, use copper backbone cables sized to support no more than 1.5 pairs for every outlet connected to the serving TR.

Terminate OSP cable on a PET. Terminate the copper backbone cable originating in the main TR or main cross-connect in each TR on 110-type, insulation-displacement wiring blocks mounted on the backboard or rack-mounted. If rack-mounted, isolated from the rack bonding busbar (RBB) and route appropriate ground to PBB for PET. Provide 110-type terminal blocks on the same backboard as the PET and in each TR for copper backbone distribution. Use intermediate cross-connects when required by the Information Communications Technology Manager.

2-3.3.1.2 Fiber Optic.

a. Use single mode fiber optic cable with a minimum of 12 strands between the main telecommunications room or main cross connect and each TR. Where required by NFPA 70® or by local regulations, fiber optic cable must be plenum-rated. Place non-armored fiber in innerduct. Furnish bullet bonding for armored fiber cabling.

b. Indicate the proper color coding of optical fiber cabling on design drawings. Use the TIA-598 jacket color coding scheme for fiber-optic (FO) cable (Table 2-3).

Table 2-3 Jacket Colors

MODE	COLOR
Single-mode (ranges between 8 and10um) (OS1)	Yellow
Single-mode (ranges between 8 and10um) (OS2)	Yellow
Multimode 62.5/125um (OM1)	Slate LEGACY
Multimode 50/125um (OM2)	Orange LEGACY
Multimode 50/125um laser optimized (OM3)	Aqua
Multimode 50/125u (OM4)	Violet or aqua
Multimode 50/125um laser optimized (OM5)	Lime green

c. Table 2-4 provides typical distances for the fiber optic cable types listed in Table 2-3. Work with the system owner to select the appropriate media type to match the requirements of the installation. Consideration technology refreshes that can be expected to occur over the life of the installed plant.

Table 2-4 Fiber Speeds

Speed Fiber Type	100 MB	1 Gb	10 Gb	40 Gb	100 Gb
OM1	1800 ft (549 m)	722 ft 220 m)	108 ft (33 m)	N/A	N/A
OM2	1800 ft (549 m)	1800 ft (549 m)	269 ft (82 m)	N/A	N/A
OM3	1800 ft (549 m)	1800 ft (549 m)	984 ft (300 m)	328 ft (100 m)	328 ft (100 m)
OM4	1800 ft (549 m)	3281 ft (1000 m)	1800 ft (549 m)	500 ft (152 m)	500 ft (152 m)
OM5	N/A	N/A	1800 ft (549 m)	500 ft (152 m)	500 ft (152 m)
SM	N/A	32800 ft (9997 m)	32800 ft (9997 m)	32800 ft (9997 m)	32800 ft (9997 m)

d. Terminate backbone fiber-optic (FO) cabling, at each end, on cabinet/rack-mounted patch panels with integrated circuit (IC) or MPT-type connectors unless otherwise required by the activity or recommended by the system manufacturer. Do not use straight tip or mechanical transfer registered jack (MT-RJ) fiber optic adapters and connectors for new construction unless specifically required for interface with existing equipment reused on installations. Provide fiber optic adapters and connectors in accordance with the appropriate TIA-604, Fiber Optic Connector Intermateability Standard (FOCIS). Fusion-splice backbone fibers to factory produced pigtails or use factory MTP® cables with breakout cassettes.

e. Coordinate with the Information Communications Technology Manager for the connector and fiber type. Table 2-5 lists some of the fiber and connector quantities and types for commercially available transceivers for 100G connections:

Table 2-5 100G Transceiver and Connector Types

Transceiver	Fiber	Qty Fiber	Connector	Distance (meters)
100G-SR10	OM3/OM4	20	24F MTP®	100/150
100G-SR10 MXP	OM3/OM4	24	24F MTP®	100/150
100G-SR4	OM3/OM4	8	12F MTP®	70/100
100G-XSR4	OM3/OM4	8	12F MTP®	300
100G-LRL4	OS2	2	LC	2,000
100G-CWDM4	OS2	2	LC	2,000
100G-LR4	OS2	2	LC/SC	10,000
10X10-LR	OS2	20	24F MTP®	1,000
100G-PSM4	OS2	8	12F MTP®	500
100G-SWDM4	OM3/OM4	2	LC	70/100
100G-SR-BD	OM3/OM4	2	LC	70/100
100G-FR	OS2	2	LC	2,000
100G-DR	OS2	2	LC	500

2-3.3.2 Horizontal Cabling.

2-3.3.2.1 Copper UTP.

a. Category 6A (CAT6A). Provide one CAT6A UTP cable to each standard 8-pin modular jack. Use only cable that has passed the Underwriter’s Laboratory (UL) LAN certification program and is labeled with UL acceptable markings. Provide plenum rated cables in accordance with NFPA 70®, or when directed by the facility safety officer or UFC 3-600-01. Do not use Category 3, 5, 5e, or 6 rated cabling in new construction or rehabilitation projects for ICT. See Table 2-3 for cable types for non-IT, OT, and Power over Ethernet (PoE). See paragraph 2-3.3.3 for passive optical network (PON) fiber requirements in the horizontal.

Note: When specifically required by other criteria or needed for the application, such as high bandwidth uncompressed video, designers may use screened or shielded twisted pair (ScTP or STP) cabling (as in Europe or secure areas).

b. CAT6A Termination. Terminate UTP cabling at the work area outlet and patch panel using an 8-pin, RJ45 type modular jack rated for the category of the installed cable. Terminate horizontal cables in the telecommunications spaces on Category 6A rack-mounted patch panels. Facilities with minimal outlet requirements (normally less than 12) may use a small cabinet or backboard-mounted CAT6A patch panel. Terminate cables from the same outlet on the same patch panel and individually identify the cables. Wire all terminations to the TIA 568, T568A configuration. Do not use the T568B wiring configurations unless specifically requested by the user and approved by the AHJ and approved by the COR for contract designs or the Government design lead for in-house designs. Do not split copper cables between multiple modular connectors.

Note: Coordinate with the Information Communications Technology Manager to determine if it is necessary to separately identify and differentiate "voice" and "data" systems.

c. CAT6A UTP Patch Cords. Use 4-pair, minimum size 24 AWG stranded UTP copper patch cords rated for Category 6A (match the horizontal infrastructure), with 8-pin modular plugs at each end. Due to performance and testing requirements, only factory-manufactured patch cords of the same category as the cabling plant are permitted. Use plenum patch cords in plenum spaces. For applications requiring a male termination, a male plug terminated link (MPTL), may be used conforming to TIA standards. Use patch cords of various lengths to terminate all required connections. Use 25% spare patch cords when requested by the technical authority. Length, color, and quantity of each must be approved by the COR for contract designs or the Government design lead for in-house efforts.

d. Cable Length. In accordance with TIA 568, limit copper data cable length to 295 feet (90 meters) from patch panel termination in the TR to the data outlet termination. PONs may exceed the 295-foot (90-meter) length. See paragraph 2-3.3.3 for PON cabling.

2-3.3.2.2 Fiber Optic.

a. Cabling. Use fiber optic cable to each outlet and endpoint only when required by the mission and approved by the Information Communications Technology Manager. Use 50/125-um diameter laser optimized (OM3) multi-mode when the user requires multimode fiber optic cable. When the Information Communications Technology Manager requires it, use single-mode fiber optic cable (OS1) or (OS2). Use plenum cables in accordance with NFPA 70®, or when directed by the facility safety officer or UFC 3-600-01.

Specify legacy fiber optic cable only when mating to existing installed base including 50/125-um diameter (OM2) or 62.5/125-um diameter (OM1) multimode fiber.

b. Termination. Terminate FO cable in cabinet/rack-mounted patch panels, and at the outlet using LC or MTP® type connectors in accordance with the appropriate TIA-604 series document. Do not use ST or MT-RJ fiber optic adapters and connectors for new construction unless specifically required for interface with existing equipment reused on installations. Use fiber optic adapters and connectors in accordance with the appropriate TIA-604 FOCIS. Use individual patch panels and distribution panels with 12 duplex LC connectors on each bulkhead. Consider using MTP® connectors on cassettes with breakouts to duplex LC to allow for future upgrades to the system. When designing bulkheads, specify that vertical or horizontal be applied universally on the project to ease labeling and administration.

c. Patch Cords. Use fiber optic patch cable types and connectors of the same type as those on the patch panels with which they are interconnecting. Use duplex patch cords. Due to performance and testing requirements, use factory manufactured pre-connectorized patch cords. Provide sufficient fiber optic patch cords, of various appropriate lengths, to terminate all fiber optic patch panel appearances, plus 25% spare. Use 25% spare patch cords when requested by the technical authority. Length, color, and quantity of each must be approved by the COR for contract designs or the Government design lead for in-house designs. Consider specifying a drawer in racks and cabinets to house spare patch cords.

2-3.3.3 Passive Optical Network and Fiber to the Network Edge Active Ethernet.

2-3.3.3.1 Passive Optical Network.

PON architecture employs optical switch ports centralized with a passive optical splitter to deliver connectivity to multiple endpoints via simplex single mode optical fibers. Obtain approval from the technical authority before designing PON infrastructure, and work with the network architect to understand the type of PON being deployed, as different splitter ratios are allowed. Loss budgets must be understood and incorporated into the design.

The horizontal portion of the PON infrastructure must be installed using a simplex optical fiber cable. Consider using a duplex optical fiber cable to the work area to future-proof the installation. Terminate it in the TR to allow the network engineer to patch into and change the passive optical splitter as the network evolves. When the network will include radio frequency (RF) over fiber, use of angled physical connectors (APC) will be required to reduce back reflections. Angle polished connectors (APC) are recommended for PON network connections. Connections between backbone cabling and cassettes and splitter cassettes may be made with MTP® or other high-density fiber optic termination methods allowing use of pre-manufactured cabling systems.

Optical network terminals (ONT) can be mounted at the desktop to provide copper connectivity to workstations and IP telephones. Small form pluggable (SFP)-based ONTs can be inserted into servers to allow direct connection into servers with the PON fiber. Standards such as ANSI/TIA-568 provide both minimum and maximum channel attenuation. Use these values for passive optical LANs within a building. PONs can permit 128 ONTs per optical line terminal (OLT) or greater. Backbone designs that aggregate 32 OLT per single mode (SM) fiber in the riser serve to future-proof the installation and simplify design. Based upon backbone fiber counts typically being available in 12 counts, this allows the designer to plan for layout.

a. TR Requirements. HVAC requirements can be reduced in TRs as PONs are, by definition, passive connectivity and will not generate heat. If only PON equipment exists in a TR, no additional HVAC loads need to be accounted for.

PON has the potential to reduce telecommunication spaces in a facility, but other systems may rely upon traditional horizontal cabling. FRCS such as Building Automation Systems (BAS), wireless access points (WAP), or enterprise survivable servers (ESS) may not aggregate into the PON infrastructure. If the decision is to have only PON infrastructure in a facility, the number of TRs per floor can be reduced to one because of the distances supported by a PON. The decision to reduce the size of the TR should be weighed against the risk of future systems not fitting into the space. A shallow TR room layout in accordance with TIA 569-E for PON accommodates the passive optical system per floor, but consideration needs to be given for:

- reduced corridor access during TR work.
- security needs of equipment and the need to have doors open for moves, adds, and changes.
- FRCS needs and real estate requirements.

For these reasons, it is recommended that an appropriately-sized TR for every 20,000 square feet of floor space, as a minimum, be maintained to support building telecommunication systems. Verify this space is adequate to house all systems.

b. Fiber Types. Consult the International Telecommunication Union – Telecommunication Standardization Sector (ITU-T) Series G recommendations for guidance on fiber specification for PON networks. For premises applications deploying 10 Gigabit-Passive Optical Network (10G-PON), ITU-T G.657 fiber can be used. For longer reaches, use bend-insensitive fiber meeting ITU-T G.652.

Loss of the optical path cannot be too high or too low. Discrete attenuation may need to be accounted for and designed into the system or the commissioning process.

Table 2-6 Maximum Attenuation

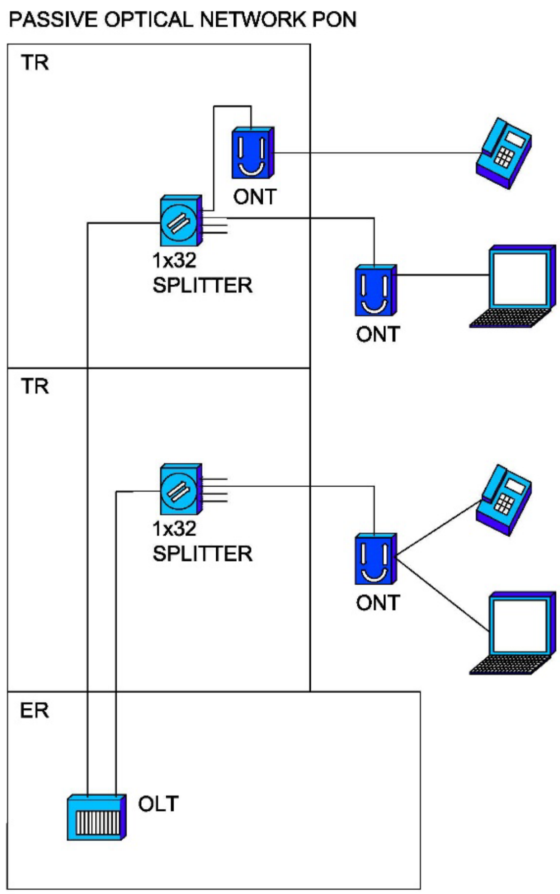
PON Type	Standard	Maximum Distance	Maximum Attenuation
EPON	IEEE 802.3ah	6.2 miles	20 dB
10G-EPON	IEEE 802.3av	12.5 miles	29 dB
GPON	ITU-T G.984	37 miles	32 dB
10G-PON	ITU-T G.987	25 miles	31 dB

Table 9 of ANSI/TIA-568 gives design parameters between 13 dB and 28 dB for premise optical network parameters. Calculate the loss budget for the network and design it to fall within this range, as follows:

Loss of cable	0.5dB/km for outside plant	1.0dB/km for inside plant
Loss of connectors	0.75 dB per connector pair	
Loss of splices	0.3 dB per splice	
Loss of splitter(s)	Varies based upon ratio and type	
Patch cord and mating loss		
Sum above losses		

Note: Plan for headroom of about 3 dB to allow for changes during the life of the cable plant.

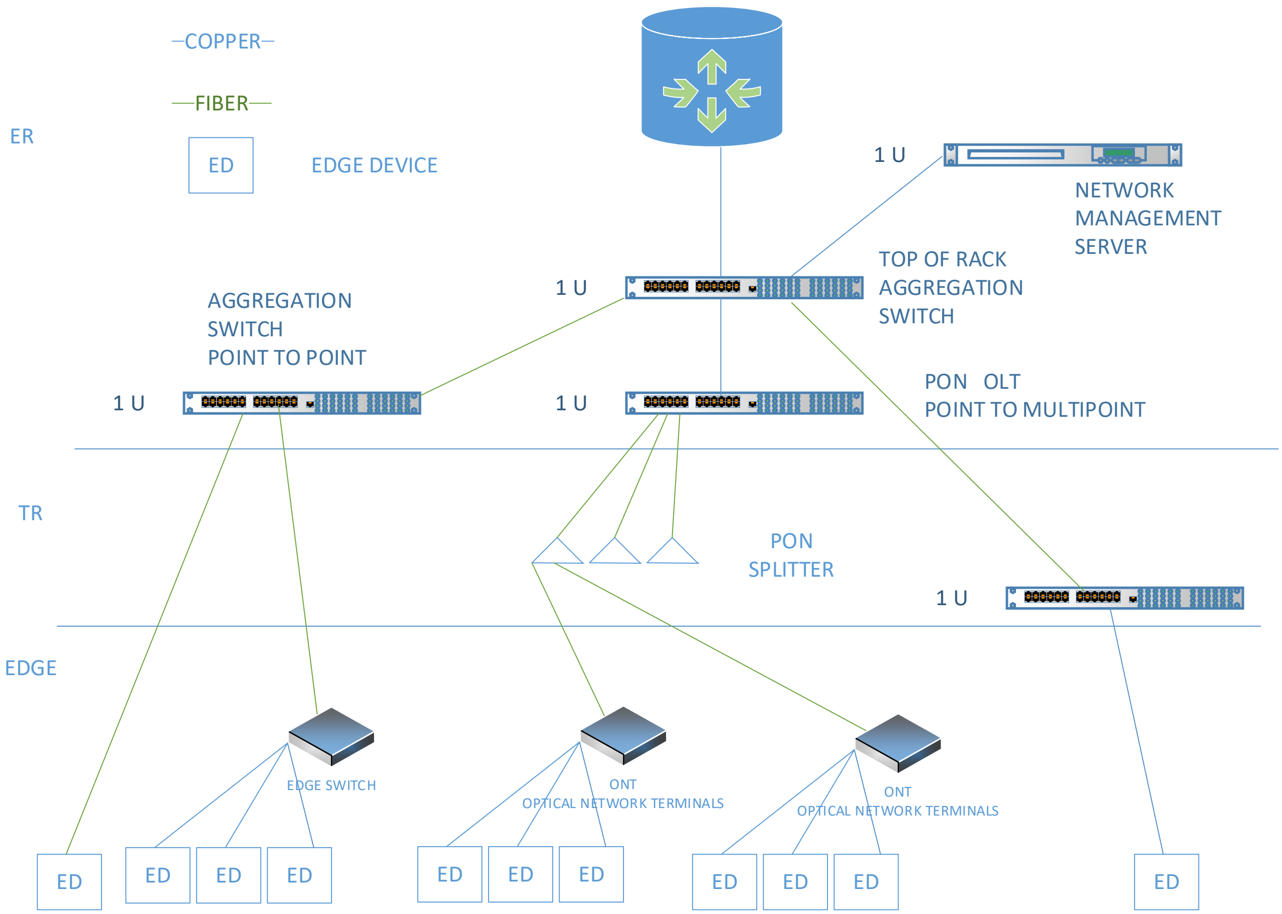
Figure 2-4 Passive Optical Network



2-3.3.3.2 Fiber to the Edge.

While most ONT/software defined access networks (SDAN) use only one fiber (standard connector (SC) angle polished connector (APC) simplex connection), consider using two fibers to each ONT/SDAN for redundancy and/or future capacity. When the network will include analog RF over glass, APC connectors will be required to reduce back reflections. Connections between backbone cabling and cassettes and splitter cassettes may be made with MTP® or other high-density fiber optic termination methods allowing use of pre-manufactured cabling systems.

Figure 2-5 Fiber to the Edge



2-3.3.3.3 Centralized Low Voltage DC Power.

a. Composite Copper/Fiber Cables. Class 2 power can be delivered via composite copper/fiber cables to ONT/SDANs and other utilization equipment that can be powered by PoE. Consider specifying cables that provide both fiber connectivity for data and copper conductors for National Electrical Code® (NEC®) Article 725 light (LPS) DC Class 2 power (low voltage at <60 volts direct current (VDC)/<100 volt-amps (VA) of power).

b. Cable Construction. Composite cables incorporate single mode fibers for network connectivity and pairs of stranded copper for low voltage direct current (LVDC) power distribution. These cables typically will have from 1 to 24 single mode fibers and 2 to 12 copper conductors ranging from 20 American Wire Gauge (AWG) to 12 AWG. Larger gauge copper will allow power to be delivered over longer distances (less voltage drop). Use a gauge of wire that will support the longest lengths needed for the application. Some composite cables also can be provided in armored configurations, indoor/outdoor jackets, or plenum rated jackets. Table 2-7 can be referred to as a guide for equipment operating between 44 and 56V input with PoE passthrough or DC power.

Table 2-7 Composite Cable Distances

Example Composite Cable Distances (1 Pair)			
	30 Watts	60 Watts	75 Watts
20 AWG	590 ft (180 m)	295 ft (90 m)	235 ft (72 m)
18 AWG	940 ft (286.5 m)	470 ft (143 m)	375 ft (114 m)
16 AWG	1,500 ft (457 m)	750 ft (228 m)	600 ft (183 m)
14 AWG	>2,000 ft (>610 m)	1,190 ft (363 m)	950 ft (290 m)
12 AWG	>2,000 ft (>610 m)	1,895 ft (578 m)	1,500 ft (457 m)

By delivering the network power over the composite cable, the power system can be centralized and provide uninterruptible power supply (UPS) backup to prevent network interruptions during building power loss.

c. Fault Managed Power (FMP). NEC® Article 726 (FMP) provides designers with the ability to deliver power for ICT appliances in excess of the 100 watts afforded to Class 2 power and PoE applications from a centralized location. Centralizing power provides centralized UPS power and administration of the system. Cabling can be routed with Class 2 power without separation in the same raceway or cable support system to the utilization equipment and is not required to be installed in conduit. Wattage available at the utilization equipment is system and cable dependent. Equipment and the cable specified must be listed by an NRTL.

2-3.3.3.4 Cabling Requirements.

Even though a PON requires only a single strand of single mode optical fiber cabling to the ONT, the ICT distribution designer should consider two or more strands at the work area to allow for future topology change. This further allows the facility owner the capability to use a mixture of peer-to-peer (P2P) and PON, as there will be instances when non-aggregated traffic will be advantageous.

2-3.3.4 Power Over Ethernet.

PoE is a method of delivering both power and data to a workstation outlet via a category cable. The proliferation of IOT devices is adding to the traditional appliances that were good candidates for PoE. In addition to WAPs, IP telephones, and IP cameras, anticipate appliances that require data and can operate on 100W will be added to the mix. Examples of these items can include displays, BAS, lighting, wayfinding, public address, clocks, and many others.

The Institute of Electrical and Electronics Engineers (IEEE) defines types of PoE according to Table 2-8.

Table 2-8 IEEE 802.3 PoE

Standard	Type	Power
802.3af	1	15.4W
802.3at	2	30W
802.3bt	3	60W
802.3bt	4	100W

2-3.3.5 Bundling

a. The table furnished in NFPA 70® and covered by Figure 2-6 is designed to keep bundles to a size that will not cause an increase in temperature that would damage the insulation. The information is presented for life safety and not performance. Elevated temperatures affect data transmission performance. This is true regardless of the source, so designers are cautioned to consider ambient temperature in the design.

b. American National Standards Institute/Telecommunications Industry Association (ANSI/TIA) TSB-184 provides information about bundle sizes. The recommendations are based upon a cable with a jacket rating of 140 °F being placed in an ambient temperature as high as 113 °F and designed to keep bundle sizes that will not allow an increase to exceed the cable rating. To comply with the NEC®, cables are not allowed to exceed their temperature ratings.

Note: The NEC® must be effective for new design projects awarded after January 1 of the year following the issuance of a revised edition unless specifically identified otherwise in contract documents.

c. Patch cords for PoE applications must be 24 AWG or larger. Bundling cable should be avoided. Reference the *Telecommunications Distribution Methods Manual (TDMM)*, 14th edition. This is a safe design parameter that will prevent problems. It allows a 48-port patch panel to have a bundle of 24 from each side.

d. Cables laid into wire basket or other non-solid tray system and not bundled do not require evaluation for heat gain, as air flow is considered sufficient. Cable trays considered 100% full generally have only 50% of the space occupied by cable, with the balance due to inefficiencies of cables not being square in shape or neatly organized.

e. It is important to understand that use of PoE is expected to increase during the life of the cabling plant. For this reason, mixing powered with non-powered devices in bundles will not remain constant throughout the life cycle of the horizontal cabling.

Figure 2-6 NFPA 70® 2020 Edition Table 725.144 Flow Chart

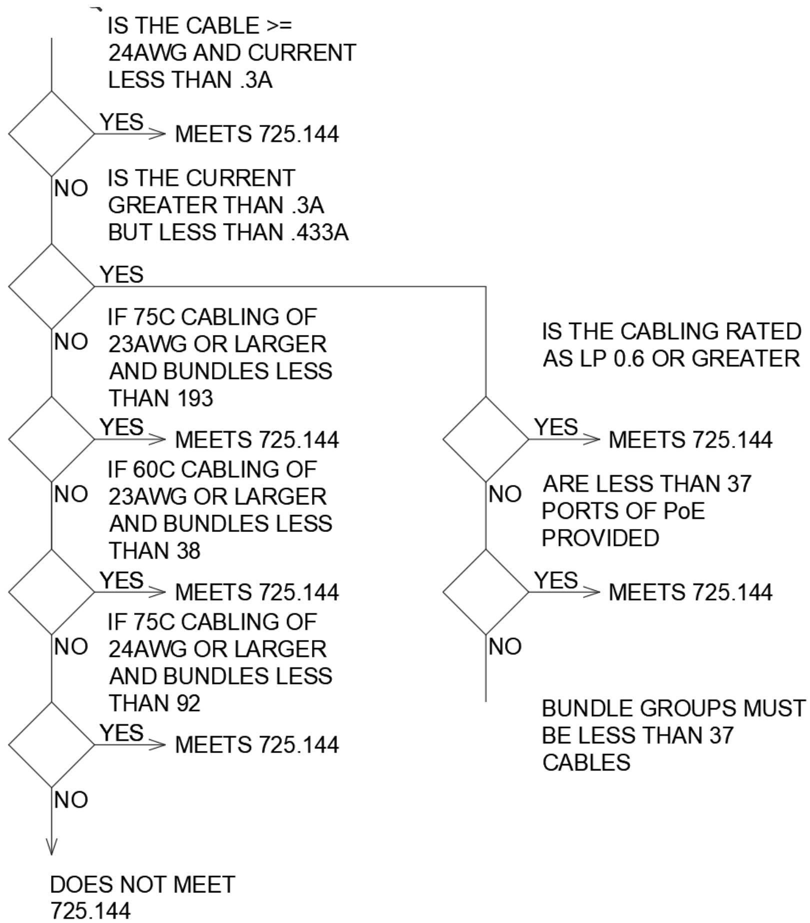


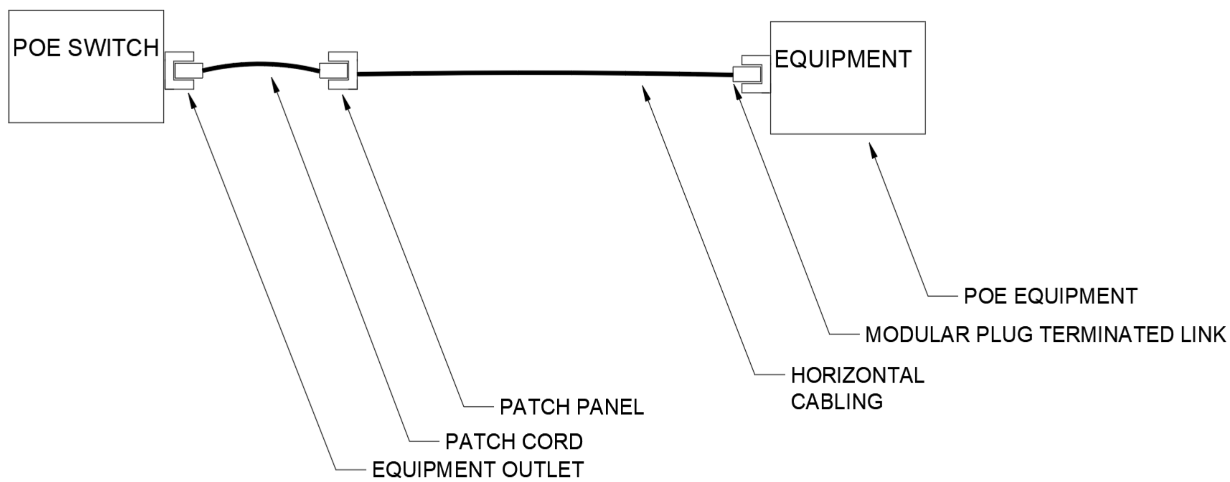
Table 2-9 Recommended Minimum Cable Types PoE

Application	Data Needs	Power Needs	Minimum Cable
BAS	Low	Low	Cat 6
AV	High	High	Shielded Cat 6A
Lighting	Low	High	Cat 6 23 AWG
WAPs	High	High	2 ea Cat 6A
Workstation outlets	High	Medium	Cat 6A

2-3.3.6 Male Plug Terminated Link Modular Plug Terminated Link.

Standards organizations including TIA and BICSI have traditionally required that horizontal cable be terminated on a workstation outlet or a patch panel. This has always precluded the field application of male RJ45 plugs because of the associated high failure rate. The proliferation of non-traditional appliances that require power and data from the horizontal equipment combined with the development of the MPTL led to inclusion and testing in the ANSI/TIA-568 standard. This is required when a female to factory patch cord is not possible.

Figure 2-7 MPTL Link Detail



MPTL connectors are designed to be field-applied to horizontal cable to allow the required quality needed for insertions over the life of the plant. The bodies have metal to assist with the dissipation of heat associated with PoE cabling. This application is useful for nontraditional IP including cameras, WAPs, and IOT appliances.

2-3.3.7 Single Pair Ethernet.

FRCS operational technology (OT) that relies on IEEE 802.3 Ethernet is evolving as standards are being published supporting single pair power over data line (PoDL) connections. IEEE 802.3cg standard for 10 megabits per second (Mb/s) lists the following types:

10BASE-T1S	Link segment (point-to-point), 4 connections, 15 meter reach, PoDL power
10BASE-T1L	Link segment (point-to-point), 10 connections, 1000 meter reach, PoDL power
10Base-T1S	Mixing segment (multidrop), 8 nodes, 25 meter reach

TIA single pair Ethernet topologies include:

SP1-400	23 AWG 400M maximum
SP1-1000	18 AWG 1000M maximum
10Base-T1S	Mixing segment (multidrop), 8 nodes, 25m reach

IoT devices will not require batteries or battery changes and can be powered from a switch with a UPS.

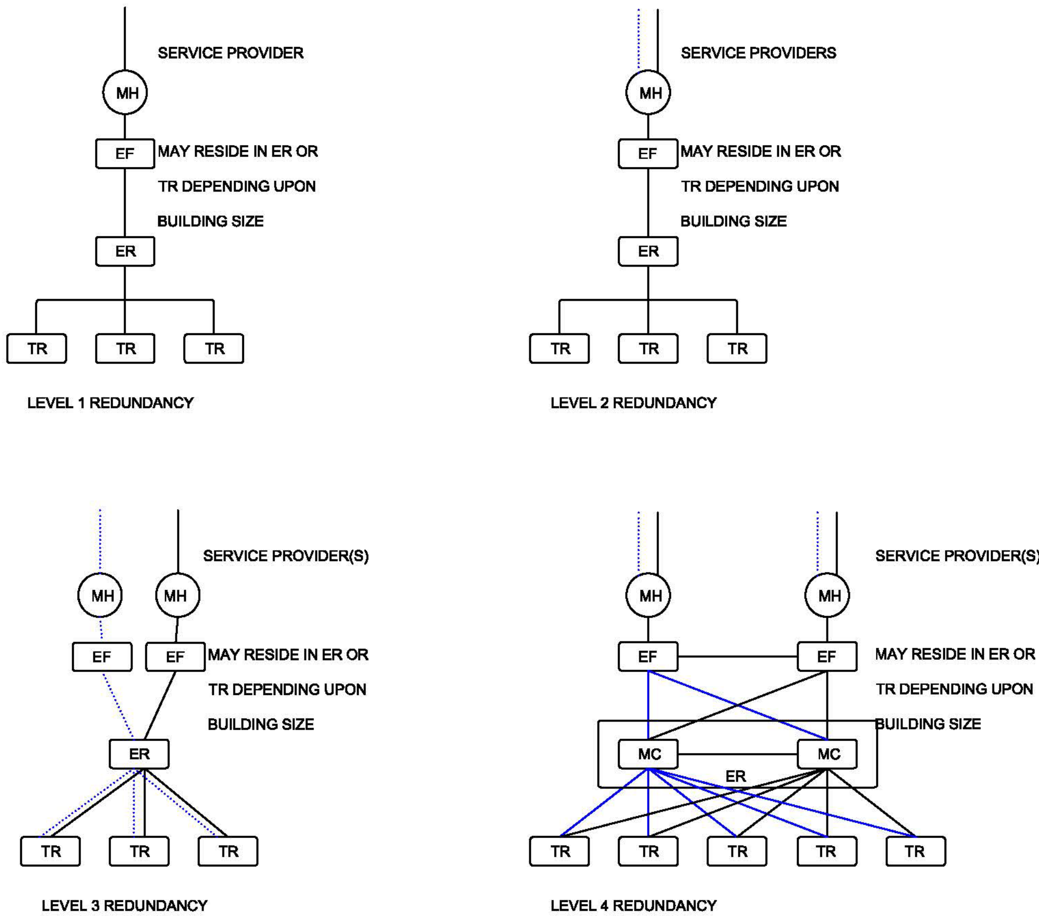
Two 10Base-T1L connectors are recognized by this UFC. They include LC style rated to IP20 and an LC style rated to IP65/67 that are included in International Electrotechnical Commission (IEC) 63171-1 and are not proprietary.

2-3.3.8 Redundancy.

Layer 1 redundancy is a function of mission requirements. Those mission requirements are covered by UFCs and other criteria and outside of the scope of this UFC. Redundancy requirements must be vetted through the proper channels. When the mission requires redundancy, the following information is included to assist in specifying a level of redundancy in the backbone to permit common understanding of the design elements. Additional information on rated levels of redundancy can be found in TIA 942 and on classes of systems in ANSI/BICSI 002 latest edition.

Four levels of redundancy are defined in this UFC. The features of each are illustrated in Figure 2-8 and further described in Table 2-10. It is important to recognize that not all areas of the building may require the same levels of redundancy. There will often be administrative areas in a facility that are collocated for efficiency of operations and will not need the same level of service. To serve all areas with the same level of redundancy would needlessly strain capital. The entire design team must be engaged early to coordinate utilities to ensure the desired outcome is reached. There will be power and cooling requirements that will need to align with the ICT to achieve a desired uptime.

Figure 2-8 Redundancy Levels



LEGEND	
TR	TELECOMMUNICATIONS ROOM
ER	EQUIPMENT ROOM
EF	ENTRANCE FACILITY
HC	HORIZONTAL CROSSCONNECT
IC	INTERMEDIATE CROSSCONNECT
MC	MAIN CROSSCONNECT
FD	FLOOR DISTRIBUTOR
BD	BUILDING DISTRIBUTOR
CD	CAMPUS DISTRIBUTOR
MH	MAINTENANCE HOLE

A	SPACE	CONTAINS	
(A)	TR	HC (FD)	DA
(B)	ER	MC (CD)	DC
(C)	EF		
(D)	ER	IC (BD)	DB
(E)	EF	IC/HC(BD/FD)	DA/DB

Table 2-10 System Levels

System Level	Description	Pathway Notes
Level 1	Non-redundant	
Level 2	Multiple service providers in the ER	
Level 3	Multiple service providers served from diverse pathways in the OSP. Backbone diversity with multiple connections but not pathway diversity in the building.	Maintenance holes (MH) should be 66 feet (20 meters) apart and ideally on opposite sides of the building.
Level 4	Multiple service providers served from diverse pathways. Backbone diversity with pathway diversity in the building.	MHs should be 66 feet (20 meters) apart and ideally on opposite sides of the building. Internal pathways should be separated by 4 feet (1.2 meters) whenever practicable or otherwise designed for pathway survivability.

2-3.4 Work Area.

A work area is the building space where occupants interact with information communications technology terminal equipment. In this UFC, consolidation points (CP), multi-user telecommunications outlet assemblies (MUTOA), and service outlets (SO) are included.

2-3.4.1 Outlets.

2-3.4.1.1 Wall-mounted Workstation Outlet Boxes.

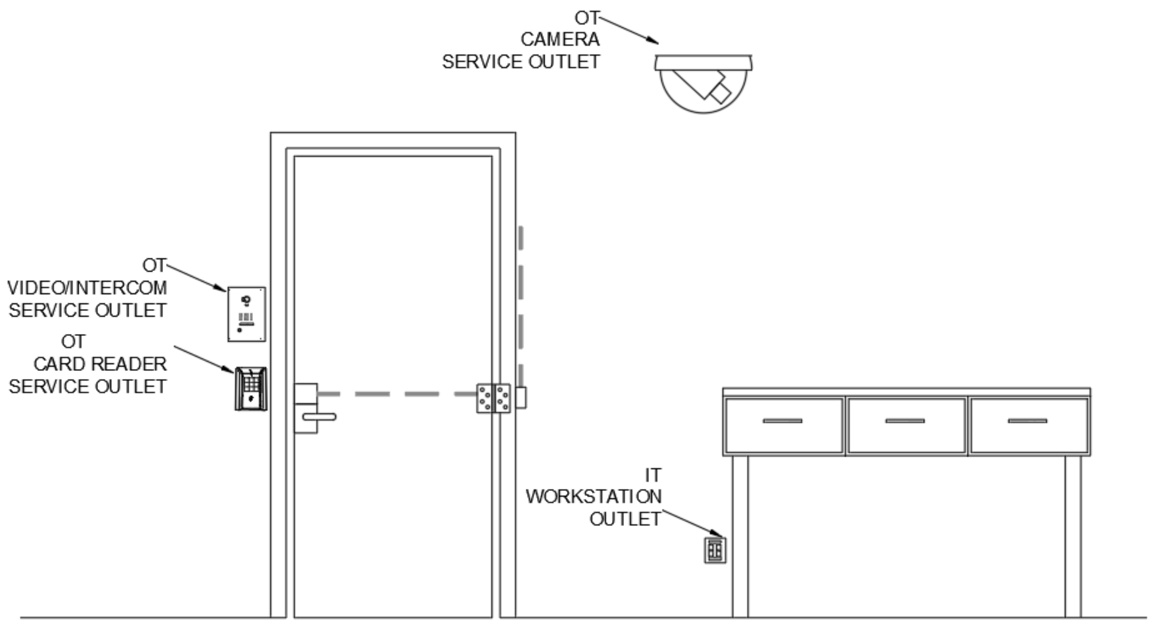
Use double gang electrical boxes, minimum standard size 4-11/16 inches (120 millimeters) square and 2-1/8 inches (54 millimeters) deep with plaster ring for connection of single gang faceplate. Design outlet boxes for recessed mounting with the faceplate flush with the wall surface, at the same height as the electrical outlets. Locate a quadruplex electrical outlet within 6 inches (152 millimeters) of all work area outlets to serve information communications technology loads associated with that outlet.

For the power outlet circuits, assume that each location of two duplex receptacles will power one personal computer with a monitor along with typical office appurtenances such as task lights, and assume that there will be no diversification of this load.

2-3.4.1.2 Service Outlet Boxes.

ANSI/BICSI 007-2020 defines a service outlet (SO) as an outlet that connects equipment to ICT infrastructure. Service outlets are typically used by FRCSs and are not subject to frequent disconnections or relocations. Service outlets need to be aligned with the operational technology (OT) equipment that they serve for mounting heights and box sizes.

Figure 2-9 Service Outlet



2-3.4.1.3 In-floor Outlet Boxes.

Use in-floor outlet boxes only if no other alternative exists for feeding systems furniture, classroom desks, lecterns in lecture halls, and other free-standing furniture. In some instances, an in-floor grid type system may be required to provide necessary flexibility. Account for environmental conditions and the maintenance of floor outlet boxes in the design.

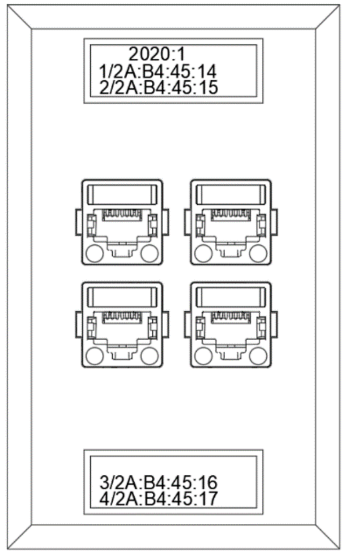
2-3.4.2 Faceplates.

2-3.4.2.1 Outlet Faceplate.

Use a single gang, four position, modular faceplate for each work area outlet. Standard configuration is two RJ-45 modular jacks and two blanks for future applications as shown in Figure 2-10. Provide other copper and fiber optic configurations to support special or legacy telecommunications systems when required.

Figure 2-10 represents a single gang faceplate with four CAT6A modules and sample labeling.

Figure 2-10 Typical Faceplate Configuration



2-3.4.2.2 Wall-Mounted Faceplate.

Use a single gang, single position modular faceplate with one wired modular jack and mounting lugs for each wall-mounted phone.

2-3.4.2.3 Coaxial Faceplate.

Use a single gang**,** single position modular faceplate with one F-type coaxial adapter or a faceplate with four modules with an F-type connector and three blanks.

2-3.4.3 Modular Jacks, Connectors, and Adapters.

Requirements in paragraphs 2-3.4.3.1 through 2-3.4.3.3 pertain to copper, fiber optic and coaxial cable jacks, connectors, and adapters. For copper systems, use the same category rating for cable, jacks, and patch panels throughout the entire system.

2-3.4.3.1 Copper Modular Jack.

Provide unkeyed Category 6A modular jacks in accordance with ANSI/TIA-568, terminated per T568A configuration. Information Communications Technology Manager approval is required for:

- use of T568B configuration to maintain existing system uniformity.
- use of keyed modular jacks where required to maintain system uniformity, security, or other user-specified reasons.

2-3.4.3.2 Fiber Optic Connectors and Adapters.

Provide unkeyed duplex LC connectors and adapters in accordance with ANSI/TIA-568. Terminate fiber optic cabling at both ends using duplex LC connectors, and use adapters at faceplates and patch panels to align and connect fiber optic cables. Consider using 12 or 24 fiber MPT assemblies with breakout cassettes to improve installation times and standardize quality with factory terminated and tested assemblies.

Information Communications Technology Manager approval is required for:

- use of other types of connectors and adapters such as SC, ST, and MT-RJ that are required to support existing systems.
- use of keyed fiber connectors with color coding where required to maintain system uniformity, security, or other user specified reasons.
- high fiber count with high density patch panels.

2-3.4.3.3 Coaxial Connectors and Adapters.

Provide F-type adapters and crimp on connectors in accordance with ANSI/TIA-568.

Terminate coaxial cabling at both ends using threaded, crimp-on connectors for CATV or other systems. Use of any other connectors, such as Bayonet Neill Concelman (BNC), requires Information Communications Technology Manager approval. Coordinate with the cable service provider where franchise agreements are in place.

2-3.4.4 Outlet Types and Density.

The number of work area outlets per square area (outlet density) required in a building varies greatly depending on the type of facility. Table 2-11 lists facility space categories, work area outlet types, and densities commonly used in military construction projects. The outlet configuration options in Table 2-11 must be selected by the proponent and the Information Communications Technology Manager. These outlet types do not address all possible user-required configurations. Provide user-defined outlets that have a corresponding valid requirement, such as multiple levels of classification or dedicated systems. Provide outlet configurations that comply with this UFC and the current versions of ANSI/TIA-568 and TIA-569. Outlet densities are provided for planning purposes when actual outlet locations are not known and cannot be determined with available information. Actual designs must include outlets in work areas, office automation outlets, private office outlets, conference rooms, and wall or access phones as necessary.

Outlet densities are based on gross area (overall building footprint without deducting for areas such as hallways, equipment rooms, and restrooms). Outlet configurations, densities, and locations for all special-purpose spaces not identified in Table 2-11 must be determined by the user and the Information Communications Technology Manager. These can be modified if it is validated (documented in writing, signed, and dated by the Information Communications Technology Manager) that mission operations require a quantity, configuration, or design other than specified in this UFC.

Table 2-11 Outlet Types

Facility Space Category	Outlet Configuration	Planning Area (ft^2(m^2)) per Outlet
Administrative space, to include private offices, conference rooms, classrooms, medical/ clinics, headquarters and special users	Two 8-pin modular (RJ45 type) outlet/connector OR One 8-pin modular and one duplex fiber optic connector OR Two duplex fiber optic connectors in a single gang outlet faceplate.	80(7.5) with a minimum of two (2) dual outlets on different walls for private offices
Open office	Two 8-pin modular (RJ45 type) outlet/connector OR One 8-pin modular and one duplex fiber optic connector OR Two duplex fiber optic connectors in a modular furniture outlet faceplate with outlet box extender	See paragraph 2-3.4.4.1.
Non-admin spaces (CDCs, chapels, recreation centers)	Two 8-pin modular (RJ45 type) outlet/connector OR One 8-pin modular and one duplex fiber optic connector OR Two duplex fiber optic connectors in a single gang outlet faceplate	500(46.5)
Barracks or dormitory space/Bachelors Quarters	Refer to paragraph 2-3.4.4.2.	
Warehouse space	Two 8-pin modular (RJ45 type) outlet/connector OR One 8-pin modular and one duplex fiber optic connector OR Two duplex fiber optic connectors in a single gang outlet faceplate	5000(465)
Wall outlet	One 8-pin modular (RJ45 type) connector in a single gang stainless outlet faceplate with mounting lugs.	As needed
Family Housing units	Refer to paragraph 2-3.3.4.3.	

2-3.4.4.1 Systems Furniture.

Provide a minimum of one systems furniture work area outlet per single occupancy cubicle and a minimum of two systems furniture outlets per cubicle designated for additional scanners, printers, copiers, or fax machines.

Coordinate with the furniture manufacturer to determine the workstation area outlets required for the furniture selected. Calculate cabling to the farthest point of each office furniture set, plus 10 feet (3 meters)

2-3.4.4.2 Barracks, Dormitory, Bachelor Quarters.

Provide one CAT6 modular jack (RJ-45 type) in each bedroom and common area (living room) of the suite configured per TIA-570.

2-3.4.4.3 Family Housing Units.

Provide a complete structured information communications technology system throughout housing unit in accordance with TIA-570. Provide Grade 1 wiring outlets (one telephone outlet and one CATV outlet) as required by TIA-570 and any other appropriate location, including attached garages. UTP cabling and modular jacks must be a minimum CAT6.

2-3.4.4.4 Utility Rooms.

Provide at least one wall-mounted information communications technology outlet in each utility room (e.g., electrical, mechanical, and telecommunications spaces) to accommodate energy management systems.

2-3.4.4.5 Elevators.

Provide a minimum of one work area outlet to the elevator machine room for each elevator. Coordinate the location with the elevator manufacturer.

2-3.4.4.6 Safety, Courtesy, and Convenience.

Provide wall-mounted telephone outlets at all logical locations to support safety, courtesy, and convenience. Examples include:

- Safety: barracks hall, laundry room
- Courtesy: building lobby/entrance
- Convenience: break rooms, rear (unmanned) entrances

2-3.4.4.7 Multi-user Telecommunications Outlet Assembly (MUTOA).

A MUTOA is a grouping in one location of several telecommunications' outlet/connectors. ANSI/TIA-568 allows MUTOAs in an open office environment. This option provides greater flexibility in an office that is frequently reconfigured. A MUTOA facilitates termination of single or multiple horizontal cables in a common location within a furniture cluster or similar open area. Cables from MUTOAs to workstations in system furniture or open offices are supported by the systems furniture raceway and the length must be calculated in accordance with ANSI/TIA-568 when establishing the total channel length. MUTOAs do not include an additional connection and are limited to terminating a maximum of 12 users. Locate MUTOAs and route cables within systems furniture in accordance with ANSI/TIA-568.

2-3.4.4.8 Consolidation Point.

A consolidation point (CP) is an interconnection point within the horizontal cabling using ANSI/TIA-568- or ANSI/TIA-568-compliant connecting hardware. It differs from the MUTOA in that it requires an additional connection for each horizontal cable run. A CP may be useful when reconfiguration is frequent, but not so frequent as to require the flexibility of the MUTOA. CPs are limited to terminating a maximum of 12 users. Locate CPs in accordance with; ANSI/TIA-568.

2-3.5 Other System Requirements.

2-3.5.1 CCTV System.

Where closed-circuit television is required, provide either a 75-ohm broadband quad-shield coaxial cable, single-mode fiber optic cable, or a category rated cable system. Coordinate with the system owner to design an RF or digital solution (such as internet protocol television [IPTV]) based upon system requirements. Ensure the correct cable is used in CCTV systems. Provide plenum cables in accordance with NFPA 70®, UFC 3-600-01, or when directed by the facility technical reviewing authority. CCTV cable distances are affected by multiple variables such as signal strength at the source, signal loss of cable, and CCTV components.

For CCTV security systems or video security systems (VSS), consult UFC 4-021-02.

2-3.5.2 CATV System.

Community antenna television systems are typically referred to as cable TV. Provide a complete system consisting of backboards or cabinets, cable, conduit, and outlets with jacks in all offices and other user required locations. Coordinate with the local CATV service provider.

Include amplifiers, splitters, combiners, line taps, cables, outlets, tilt compensators and all other parts, components, and equipment necessary to provide a complete and usable system. Include the head end amplifier as part of the system when required by the local provider. Passive CATV devices must support 1 GHz bandwidth.

Provide an ANSI/TIA-568- and NFPA 70®-compliant system. Use a star topology distribution system with each CATV outlet connected to a TR with a feeder cable or a drop cable, and each TR connected to the head end equipment with a trunk cable. Provide a high-quality signal to all outlets with a return path for interactive television and cable modem access. The system must operate within the 5- to 1000-MHz bandwidth using 1000 MHz passive devices and a minimum of 750 MHz active devices. Provide a minimum signal level of 0 decibel millivolts (dBmV) (1000 microvolts) and a maximum of 15 dBmV at 55 and 750 MHz at each outlet.

a. Cabling. Use a combination of 75-ohm broadband quad-shield coaxial cable, hard line, or single-mode fiber optic cable system. For fiber optic cables, follow horizontal and backbone cabling requirements. For coaxial systems less than 295 feet (90 meters) from head end equipment to the TR, or from TR to TR, provide RG-11 coaxial trunk cable as a minimum, and calculate the loss budget. For systems exceeding 295 feet from the head end equipment to the TR, or from TR to TR, consider using 625 series cable to reduce system losses and calculate the loss budget. Use RG-6 coaxial cables for drops from the TR (or head end) to the wall outlet. Do not use RG-59 for CATV projects.

The Telecommunications Manager and service provider may require a category cable system in lieu of an RF distribution system. Coordinate with each and provide a complete operable system.

b. HDBaseT™. HDBaseT™ is a trademark of the HDBaseT Alliance. This standard allows the transport of uncompressed ultra-high definition video, digital audio, power, Ethernet, USB 2.0 and other AV control over a single category cable up to 328 feet (100 meters) in length. Support for High Definition Copy Protocol (HDCP) high-bandwidth digital content protection is embedded in the standard to support the ability to use protected content without the 7ms violation breaking the link.

100 watts of power is supported by sending 25 watts over each of the four pairs in a horizontal cable. Power over HDBaseT™ is abbreviated as POH. HDBaseT™ 3.0 includes aggregate data rates of 16 Gb/s. Cat6A screened must be specified in the design. Consider specifying cabling with 22 AWG and screened conductors.

Supporting uncompressed video at 18 Gb/s over High Definition Multimedia Interface (HDMI) can be challenging to design due to cable distance limitations and cable size. Use of horizontal cabling as supported by HDBaseT™ offers flexibility to deliver AV solutions using standard 8P8C connectors and cabling.

2-3.5.3 WAP.

When a wireless local area network (WLAN) system or a wireless intrusion detection system (WIDS) is required, design in accordance with TIA Telecommunications Systems Bulletin 162-A (TSB-162-A) and ANSI/BICSI 008-2018. Give careful consideration to:

- building type
- availability requirements
- uses of the system RTLS
- bandwidth requirements

- coordination of systems, FRCS, IOT, and guest Wi-Fi
- system manufacturer recommendations
- facility type and use

2-3.5.3.1 Existing Facilities,

Once the needs assessment has been completed and the type of service determined, the next step is to create a layout of expected locations for access points. This will be followed up by a site survey. Based upon the output of the site survey, placement of access points in the design follows.

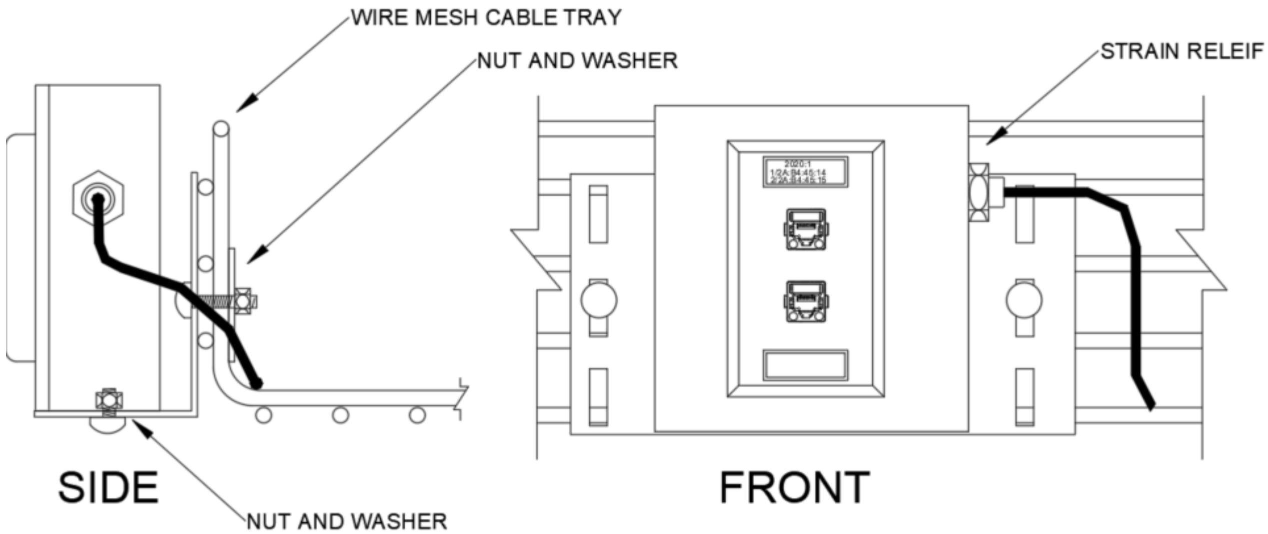
The IEEE 802.11ax, WiFi 6 by the Wi-Fi Alliance, is a 10 Gps application necessitating a Category 6A cable for 328 foot reach. The current best practice and compliance with TIA TSB-162-A recommends use of two category 6A (or higher) horizontal cables or OM3 (or higher) optical fiber cabling. This offers flexibility to use one of the horizontal cables to connect to additional WAPs when commissioning structures when data rates per WAP are less than 10 Gps. IEEE 802.11be uses connectivity greater than 10 Gps, requiring two category 6A cables per WAP.

a. Interior Layout. Work with the network architect to understand density requirements for number of users and use cases potentially including RTLS or other applications. Signal propagation best practice will require use of predictive RF design software to produce heat maps to determine the best layout. The commissioning signal survey may require adjustment in positions and quantities of WAPs that the designer must consider. If predictive RF design software is not available, the radius of the coverage area should not exceed 43 feet (13 meters) (based upon a standard radio in an office environment). Use hexagonal shapes to determine needed overages. Coordinate with the facility to provide TIA-606 compliant administration including location of above ceiling infrastructure.

b. PoE Wireless. NFPA 70®, the NEC®, requires that cables not be allowed to exceed their temperature ratings. The *Telecommunications Distribution Methods Manual*, 14th edition, gives guidance that bundles should not exceed 24 cables. Cables laid loosely in wire mesh cable trays and similar installations improve air flow around cables and reduce heat dissipation. Refer to additional PoE information in this chapter.

c. Horizontal Connection Points. It is advantageous to allow for maximum flexibility of final placement of WAPs. When designing an HCP, allow for a minimum of two permanent link connections for each WAP that is anticipated to be 802.11ax or higher.

Figure 2-11 WAP Outlet Detail



Provide two twisted-pair cables, Category 6A terminated on standard 8-pin modular connectors or two fiber multimode optical fiber strands, OM3 or higher for each wireless access point. Install the WAP cabling infrastructure in the same manner as other information communications technology outlets required in this UFC. Include the cable tray and conduit or J-hooks to support the cable connected to the WAP. Use of “J” hooks, flexible cable tray(s), and alternative support systems specifically certified for the cable used is permissible to support the WAPs from the cable tray. Do not exceed a 50 percent fill ratio for the “J” hooks. Support horizontal cabling to distribution areas in cable trays. Patch cables must match the cable rating.

Confirm power with the Telecommunications Manager if the WAP appliances will not be PoE-powered.

2-3.5.4 Emergency Radio and Cellular Distributed Antenna System (DAS).

2-3.5.4.1 Emergency Radio Codes and Standards.

- NFPA 1221
- NFPA 72® 24.9

2-3.5.4.2 Approval.

These radio systems are operating on frequencies assigned by a licensing authority to a jurisdiction, and coordination with the license holder and approval by the frequency manager or the FCC are required prior to installation. Coordination with the license holder should include a written approval.

The AHJ may require a permit be issued that is renewable after successful testing. This permit may be a condition precedent to an occupancy permit.

2-3.5.4.3 Cabling.

Cabling must be plenum-rated. Backbone cables are required to route through a 2-hour rated pathway from the donor antenna to the equipment enclosure matching the building's fire rating. Coordinate with the Fire Protection engineer for satisfaction of this requirement. Mount to the bottom of the communication tray where room is available or in a divided cable tray.

Connection between the backbone cables and the antenna cables must be made within an enclosure that matches the building's fire rating. Provide a 2-hour rated room to house the equipment.

In facilities where emergency responder radio coverage is required and such systems, components, or required equipment could have a negative impact on the normal operations of that facility, the fire code official has the authority to accept an automatically activated emergency responder radio coverage system. Reference NFPA 1221.

2-3.5.4.4 Coverage Area.

a. Design coverage and testing in accordance with NFPA 1221, Chapter 9. Predictive modeling software is recommended for design.

b. NFPA 1221 divides coverage into two categories. Critical areas are areas considered critical by the Fire Protection engineer. Examples include fire command centers, fire pump rooms, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, and sprinkler sectional valve locations. These areas are required to have 99 percent floor area radio coverage. General building areas must be provided with 90 percent floor area radio coverage.

c. NFPA 1221 defines the requirement to have minimum inbound signal strength sufficient to provide usable voice communications. As this is difficult to quantify for design, the 2021 International Fire Code® (IFC®), Section 510 (a) 510.4.1.1 minimum signal strength of -95 dBm is recommended for use. The building is considered to have acceptable emergency responder radio coverage when signal strength measurements in 95 percent of all areas on each floor of the building meet the signal strength requirements of -95 dBm receivable and the agency's radio system can receive a signal strength of -95 dBm from transmissions inside the building.

d. Buildings may be well-served from existing terrestrial sources and not require radio communications enhancement systems. A survey of the signal strength outside the building combined with RF predictive software can go a long way in determining any need for enhancement. Equip buildings and structures that cannot support the required level of radio coverage with a system that includes RF-emitting devices certified by the radio licensing authority to achieve the required adequate radio coverage.

e. Design radio enhancement systems to support two portable radios simultaneously transmitting on different talk paths or channels, where the facility owner has required the radio enhancement system to support more than one channel or talk path.

f. In addition to quantitative signal strength requirements, qualitative requirements mandate that the signal have a delivered audio quality (DAQ) of 3.0 for either analog or digital systems, meaning that speech is understandable with slight effort, only requiring occasional repetition due to noise or distortion.

g. Consider spaces for pathway to a donor antenna and spaces for enhancement equipment during the design phase unless sure that enhancements will not be required. Drywall and glass must be installed in a building before preliminary functionality testing can be effective. This sometimes occurs late enough in the project that adding an enhanced system affects building occupancy dates.

2-3.5.4.5 Design Personnel Licenses and Certifications.

- general radio operator’s license issued by the Federal Communications Commission (FCC)
- manufacturer certificate or nationally recognized organization certification

2-3.5.4.6 Isolation.

When a two-way radio communications enhancement system is installed, isolation between the donor antenna and all interior antennas must be a minimum of 20 dB under all operating conditions. Predictive RF design software should assist with proper placement of antennas near windows to maintain proper isolation.

2-3.5.4.7 Enclosures.

Equipment enclosures must be NEMA 4 or NEMA 4X, except for battery enclosures that require ventilation, and those must be NEMA 3R.

2-3.5.4.8 Interfaces with Facility Fire Alarm Control Panel.

When a two-way radio communications enhancement system is installed, numerous supervisory and trouble notifications must be reported to the Facility Fire Alarm Control Panel (FACP).

2-3.5.4.9 Testing.

Test in accordance with NFPA 1221, Chapter 11. The building floor is divided into 20 equal size test areas and a calibrated portable radio of the model used by the agency is used to talk through the agency’s radio communications system. A test is conducted in the center of each test area as a pass/fail. Quantitative and qualitative readings are gathered, and a report produced. A spectrum analyzer must be used to ensure oscillations are not being generated by the amplified signal. The report must include the amplifier gain values and the results and is kept on file with the building owner.

2-3.5.4.10 Power Supply.

a. Provide at least two independent and reliable power supplies for all components, one primary and one secondary. The primary must be from a dedicated branch circuit and comply with NFPA 72®. The secondary power source must supply 12 hours of 100 percent system operation and be arranged in accordance with NFPA 10.6.10, or a battery system with 2 hours of 100 percent system operation and an automatic-starting generator service with a dedicated branch circuit arranged in accordance with NFPA 72®.

b. NFPA 1221 requires power supplies to be monitored by the system the same as for a fire alarm system.

c. Provide a dedicated annunciator within the fire command center to annunciate the status of all RF emitting devices and active system component locations. This device must provide visual and labeled indications of the following for each system component and RF-emitting device:

- normal AC power
- loss of normal AC power
- battery charger failure
- low-battery capacity (to 70% depletion)
- donor antenna malfunction
- active RF-emitting device malfunction
- active system component malfunction

d. The communications link between the annunciator and the two-way radio communications enhancement system must be monitored for integrity.

e. An emergency power off (EPO) switch may be required by the Fire Protection engineer to kill both the normal and redundant power supplies simultaneously.

2-3.5.4.11 Types of Systems.

Work with the building owner to determine the appropriate type of distribution system for the facility. Options are summarized in Table 2-12.

Table 2-12 Facility Distribution System Design Options

	System		
	Passive	**Active**	**Hybrid**
Distance	Limited	Extended	Extended in backbone
Horizontal Cable	Coax	Fiber or copper	Coax
Backbone Cable	Coax	Fiber	Fiber
Cost	Low	High	Medium
Advantages	• Lower cost, electronics for digital conversion not required • Power not required at the antennas	• Longest reach • Shares common building system infrastructure	• Extended backbone distances • Less expensive than active
Disadvantages	• Link budget calculations add to design complexity • Limited distance	• Dedicated power required at access points and antennas • Most expensive	• Installation complexity with multiple media types

2-3.5.4.12 Passive DAS Topology.

Passive DAS are typically used in spaces smaller than 80,000 square feet. They use coaxial cable, splitters, repeaters or bi-directional amplifiers and antennas to distribute the signal.

Passive systems can be single or multi-carrier and are cost-effective solutions. More extensive design adds to the complexity of the system.

2-3.5.4.13 Hybrid DAS Topology.

Hybrid systems combine use of active fiber backbone cable to intermediate nodes and distribute signals to passive antennas via coaxial cable.

2-3.5.4.14 Active DAS Topology.

Active DAS systems are often deployed in high-rise buildings and stadiums where distances between the source and antennas are long. They use a fiber optic head-end distribution to the intermediate nodes, and fiber or copper structured cabling for distribution to the antennas. The fiber is an APC solution, and the designer will need to work the selected solution vendors to design the system. Power is required for the access points and other equipment.

2-3.5.4.15 Cellular Coverage.

Work with the system owner to determine how the signal will enter the facility. The most common methods include:

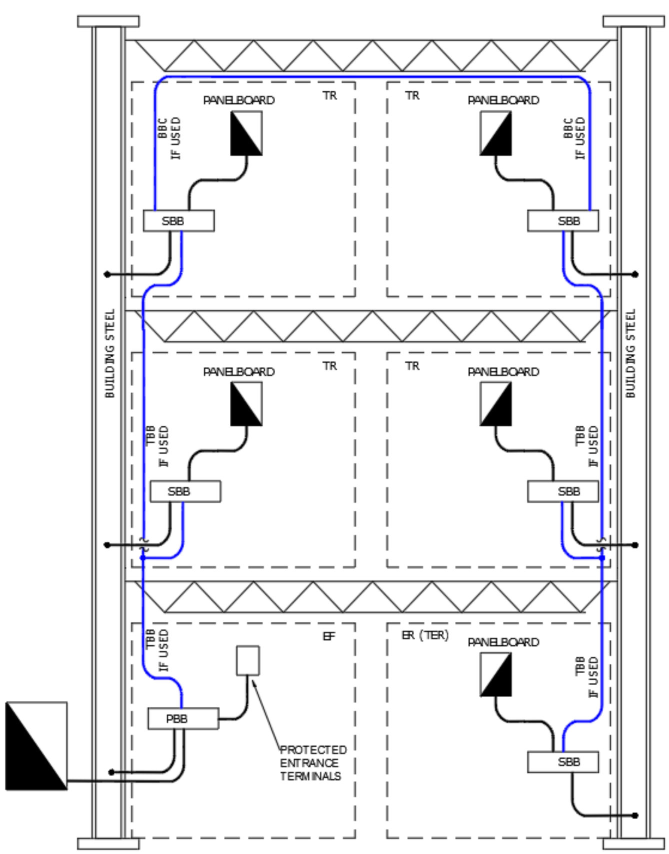
- Off air: The DAS uses an external donor antenna to capture cellular signals from local cell towers.
- Base Transceiver System (BTS): The DAS draws signals directly from the provider via optical fiber cables.
- Small cell: The DAS uses an internet connection to create a secure link to the carrier's network.

Coordinate and get approval for any devices that will amplify or distribute a licensed carrier's signals. If a multicarrier system is possible, all vendors are required to provide written approval of the design.

2-4 GROUNDING, BONDING, AND STATIC PROTECTION.

Comply with NFPA 70® for grounding and bonding requirements. Provide a telecommunications bonding and grounding system in accordance with TIA-607. Refer to Figure 2-12. Building grounding systems are covered in UFC 3-520-01.

Figure 2-12 Telecommunications Grounding and Bonding Infrastructure



BBC	Backbone Bonding Conductor
EF	Entrance Facility
ER	Equipment Room
GEC	Grounding Electrode Conductor
PBB	Primary Bonding Busbar
SBB	Secondary Bonding Busbar
TBB	Telecommunications Bonding Backbone
TBC	Telecommunications Bonding Conductor
TR	Telecommunications Room
TEBC	Telecommunications Equipment Bonding Conductor
RBB	Rack Bonding Busbar

Note: TIA-607 identifies a bonding conductor known as the telecommunications bonding backbone (TBB) which is intended to equalize potentials between TRs. The impedance of the TBB increases with length, thereby reducing its ability to equalize potentials between TRs. The ICT designer must consider that the TBB for a large site may be very costly to achieve. As an alternative, the SBB in each TR and PBB can be bonded to the electrical panel board in the space and to structural steel where applicable. Install bonding conductors in the shortest and most direct paths feasible.

Table 2-13 Grounding Terminology

TIA-607-B Term	TIA-607-C Term
Grounding equalizer (GE)	Backbone bonding conductor (BBC)
Telecommunications main grounding busbar (TMGB)	Primary bonding busbar (PBB)
Rack grounding busbar (RGB)	Rack bonding busbar (RBB)
Telecommunications grounding busbar (TGB)	Secondary bonding busbar (SBB)
Bonding conductor for telecommunications (BCT)	Telecommunications bonding conductor (TBC)

2-4.1 Cable Entrance Grounding.

Connect all metallic shields and strength members for outside plant cable entering a building to the electrical service grounding electrode system in accordance with NFPA 70®, Article 800. Bond the OSP cable shield, armor, and metallic strength member to the main building ground as close as possible to the building point of entrance with a No. 6 AWG or larger ground wire. When possible, preference is OSP cabling straight to the PET and not splice case. Use a non-bonded splice case for the transition from OSP-rated cable to interior-rated cable where a splice case is required by the AHJ. If the OSP cable extends past 50 feet (15 meters), bond the metallic strength member to the TBB with a No. 6 AWG or larger copper ground wire, as close to the conduit egress point as possible.

2-4.1.1 Protected Entrance Terminals.

Terminate all incoming OSP copper cables on UL-listed primary protector blocks located within the building entrance terminal cabinet. Provide protector blocks equipped with 5-pin solid state, gas, or hybrid protector modules for the number of pairs terminated plus 25 percent. Bond the protector blocks to the main electrical service ground via the PBB or SBB with a No. 6 AWG or larger copper ground wire.

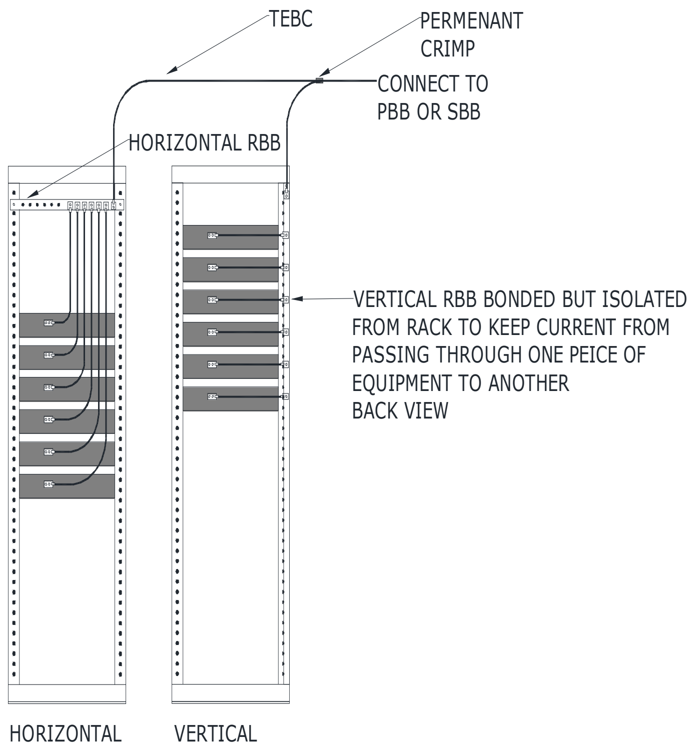
2-4.2 Telecommunications Spaces Bonding and Grounding.

Bond all telecommunications spaces and infrastructure in accordance with TIA 607 where applicable. When building steel is used as a grounding (earthing) electrode, the ICT distribution designer must specify that the telecommunications busbars be installed as close as practicable to a structural steel member within the ER, TR, or EF.

2-4.3 Telecommunications Rack and Supporting Structure.

Bond all telecommunications racks and supporting metallic structures (cable trays, ladders, conduits and baskets) in accordance with TIA-607and NFPA 70®. Non-continuous distribution systems (stub-ups, J-hooks) do not require bonding. Unless otherwise requested by the Telecommunications Manager, do not design rack bonding per Example C in TIA-607. See Figure 2-13 for allowable rack bonding methods. Only bond appliances that have manufacturer bonding connections available.

Figure 2-13 Rack Grounding and Bonding



2-5 TELECOMMUNICATIONS SYSTEM ADMINISTRATION.

Provide administration for the complete telecommunications system in accordance with TIA-606. Determine the minimum class of administration by evaluating the size and complexity of the premise infrastructure. Ensure the format for identifiers is backwards-compatible with TIA-606 for installations in existing facilities or per ISO/IEC TR4763-1 for new facilities unless otherwise directed by the Telecommunications Manager. Consult Appendix A and coordinate with the Telecommunications Manager for any additional service-specific labeling or administration requirements. Color-coding of telecommunications infrastructure and components is recommended, but not required. The DOR must identify the class of system in design documents.

CLASS 1 – Single equipment room (ER)

- the only telecommunications space (TS) administered
- no telecommunication rooms (TRs) and no cabling subsystem 2 and 3 cabling or outside plant cabling systems to administer

CLASS 2 – Single building served by multiple TRs

Identifiers included in Class 1 administration plus:

- one or more TRs within a single building
- cabling subsystem 2 and 3 cabling, multi-element bonding and grounding systems and fire stopping

CLASS 3 – Campus environment

Identifiers included in Class 2 administration plus:

- multiple buildings and building pathways, spaces, and outside plant elements

CLASS 4 – Multi-site (multi-campus)

Identifiers included in Class 3 administration plus:

- campus or site identifier

Labeling must be mechanically printed, except those requiring signatures, and must be legible.

2-6 TELECOMMUNICATIONS SYSTEM TESTING.

Installed backbone and horizontal telecommunications cabling and connecting hardware must meet minimum performance requirements and be tested in accordance with ANSI/TIA-568. Provide reports of all test results and certifications to the proponent and Telecommunications Manager upon completion.

2-6.1 Unshielded Twisted Pair Cabling and Connecting Hardware.

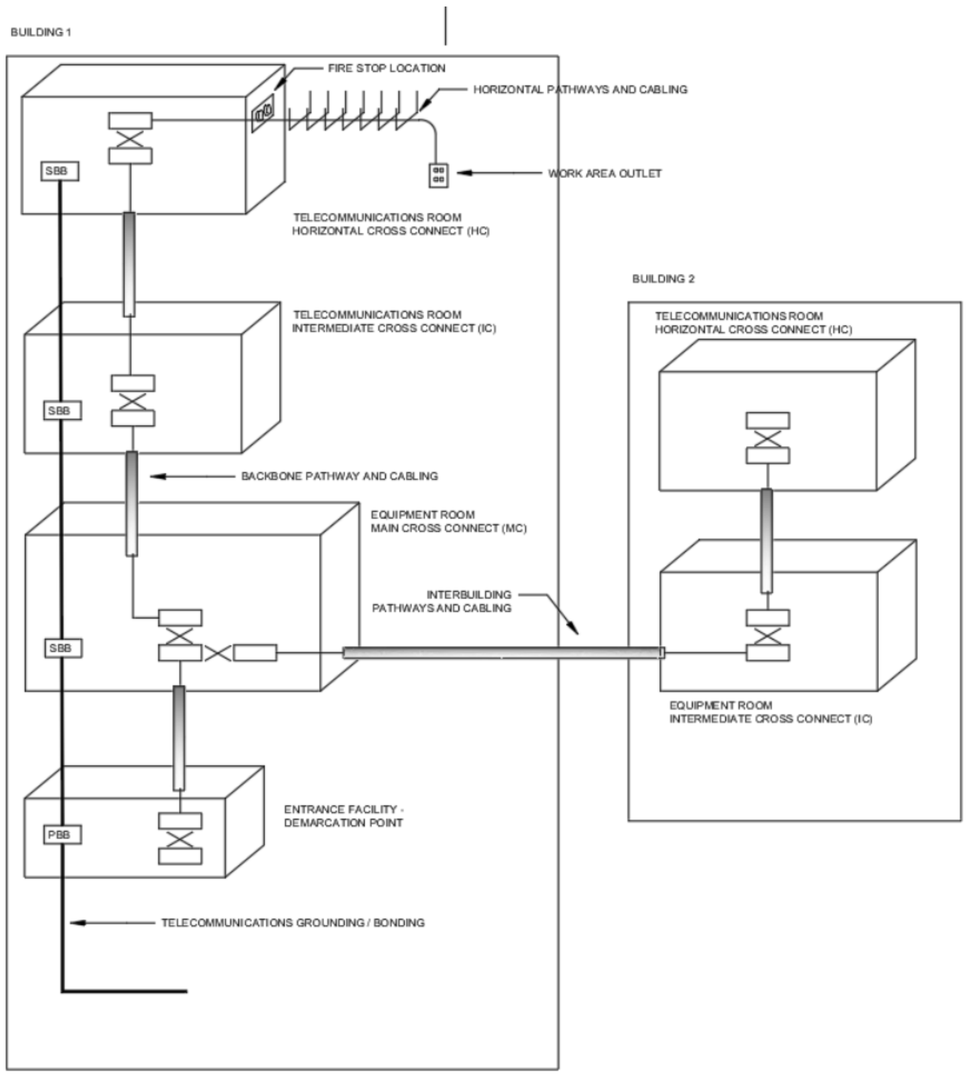
Perform all required testing to ensure minimum performance requirements are met in accordance with ANSI/TIA-568. There are different levels of certification test equipment for field testing and the correct level must be used to certify cabling plant.

Table 2-14 Certification Test Equipment Levels

Level	Frequency	Cable Category
IIe	100 MHz	5e and class D
III	250 MHz	6 and class E
IIIe	500 MHz	6A and class EA
IV	1000 MHz	8 and class F/FA*

*Currently, field tester accuracy to cover Class F cabling to 1000 MHz is not defined.

Figure 2-14 Telecommunications Labeling



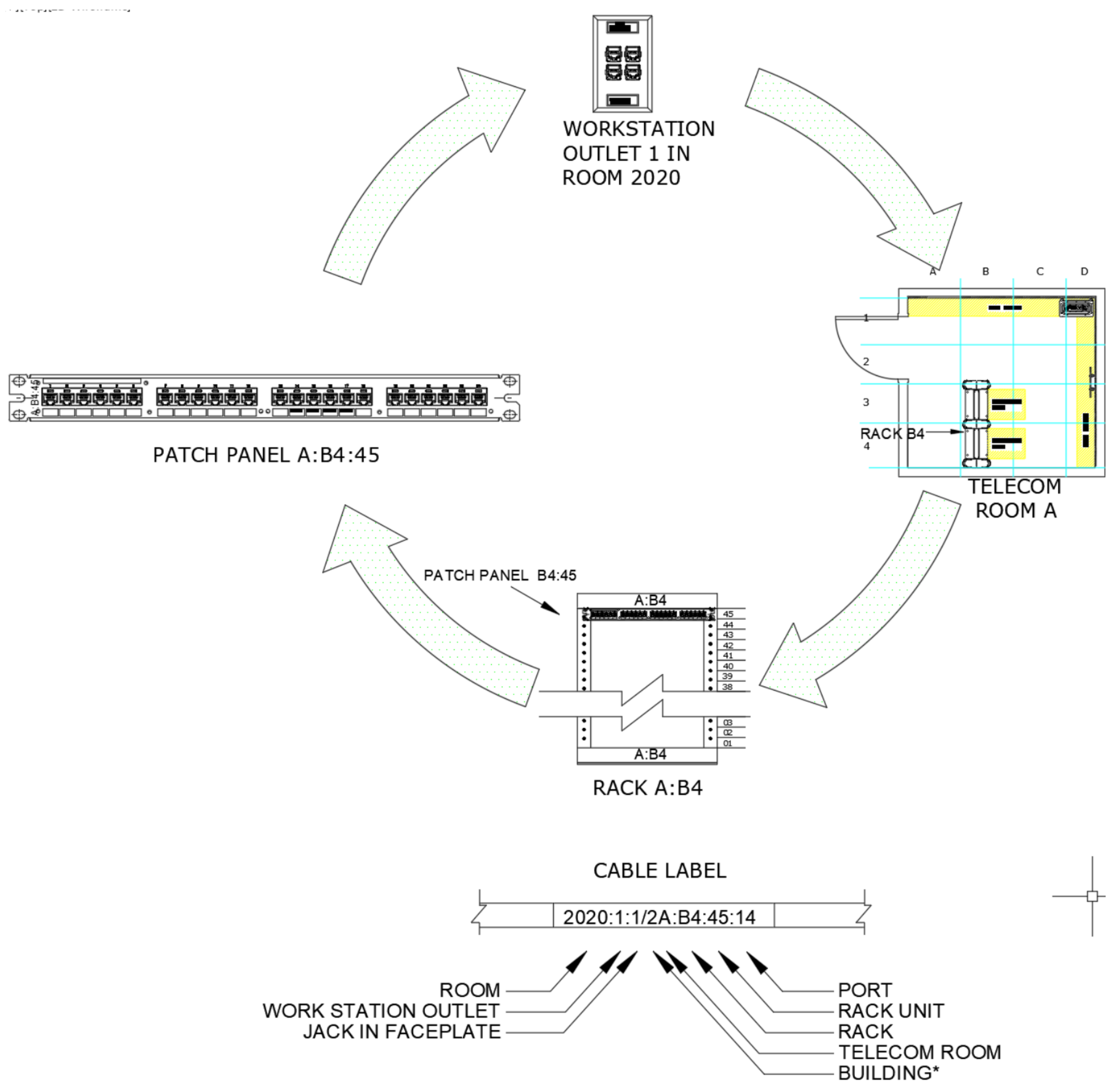
TELECOMMUNICATIONS INFRASTRUCTURE REQUIRED LABELING

Telecommunications spaces
• Entrance (where telecom networks enter the building)
• Telecommunications room
• Equipment room with switches, servers and routers

Pathways & Cabling
• Horizontal pathways
• Backbone pathways
• Interbuilding pathways

Fire Stopping Locations
Bonding Locations
Grounding Locations

Figure 2-15 Sample Labeling System



2-6.2 Fiber Optic Cabling and Connecting Hardware.

Perform all required testing in accordance with ANSI/TIA-568 on the link. Test the link at both standard frequencies bidirectionally for multimode and single mode. The testing method must comply with TIA 526-7A using the single jumper method.

An optical time domain reflectometer (OTDR) is required for all OSP and inside plant lengths in excess of 500 feet (152 meters) and when requested by the Telecommunications Manager using the launch cables and exit cables of the required length for the fiber type.

2-6.3 PON Testing and Certification.

Bidirectional loss at both 1310 nanometers and 155 nanometers must be conducted between the OLT and every cable in every ONT connected through the splitter.

2-6.4 Coaxial Cabling and Connecting Hardware.

Perform all required testing to ensure minimum performance requirements are met in accordance with ANSI/TIA-568.

2-6.5 Test Plan.

The contractor must submit for USG review a test plan of all proposed cabling and equipment being installed under the project. After the contractor has completed the installation and testing of the information technology system, the contractor must submit a test report for all fiber and copper cabling. The contractor's Registered Communications Distribution Designer (RCDD) must approve both the test plan and the test report before submitting to the USG.

Note: Test plans for small scale projects (less than 5,000 square feet (464.5 square meters)) described in paragraph 2-1.2 do not require RCDD approval.

The test plan must include, along with all testing system reports, a complete project test summary spreadsheet with indexed room numbers, outlet labels, jack labels, and the pass/fail status, and causes for failures along with a total number of outlets installed, jacks/cable runs installed and the total number of jacks/cable runs that passed and failed the tests. Failed tests require the contractor to correct the failures prior to turnover of the system. Testing, data, and analysis is required by the USG at the contractor's expense if original testing does not prove adequate for identifying causes of failures, and if the USG is responsible for paying for any repairs not within the original scope of contract.

The test plan will include subsequent testing of 5% of the cabling plant with the USGs quality assurance (QA) representative to verify that the contractor's quality control (QC) program is functioning correctly. Unsatisfactory results of the QA verification will require additional remediation of the QC plan.

2-7 COMMISSIONING.

Commissioning (Cx) of the telecommunications system must be accomplished for projects where more than passive equipment is provided. Cx must begin in the design phases and may extend beyond the building occupancy date. The designer must edit applicable Unified Facilities Guide Specifications (UFGS). They must include requirements for pre-functional checklists and submission of prefunctional testing, submittals reviewed and approved by the Cx Agent (CxA), development of functional checklists by the Commissioning Manager (CxM), establishment of roles and responsibilities, and test reports similar to those provided for mechanical and electrical systems. Commissioning activities must include required cybersecurity activities for FRCS systems in accordance with UFC 4-010-06.

Performance testing and operation of systems is required to ensure systems work in a coordinated manner and according to manufacturers' specifications, codes, rules, and standards. Commissioning also provides testing of failure modes and operational procedures in all modes, under all electrical conditions, both isolated and integrated with other systems. Commissioning a building system must clearly identify real and potential issues with the building system and the affiliated subsystems during all phases of the project.

2-8 NETWORK EQUIPMENT.

Active network equipment has unique requirements and considerations beyond the scope of this UFC. Any active equipment (controllers, IP switches, radios, IP-based components) must be designed in accordance with UFC 4-010-06, and may require a corresponding 25 05 11 specification.

CHAPTER 3 OUTSIDE PLANT CRITERIA

3-1 INTRODUCTION.

3-1.1 Scope.

This UFC provides a consolidated source of USG-approved standards and practices to facilitate the planning, design, construction, and installation of exterior unclassified OSP information communications technology infrastructure. This includes the minimum requirements for OSP spaces, pathways, cabling, and distribution systems. Special considerations may be given to unique circumstances that dictate a need to exceed the minimum criteria defined herein.

Standards and practices for planning, design, construction, and installation of classified information infrastructure must be coordinated with a Certified TEMPEST Technical Authority (CTTA) and Designated Accreditation Authority (DAA) responsible within that area. Hardened Carrier Distribution Systems (HCDS) are not within in the scope of this UFC and are expected to be fully compliant with CNSSI 7003.

3-1.2 Applicability.

Criteria and standards within this UFC are the minimum to provide DoD base/post/camps/stations (B/P/C/S) with efficient, economic, sustainable, scalable, maintainable, and reliable OSP information communications technology infrastructure. They apply to new work and upgrades and are not intended to be retroactively mandatory to existing, in-place infrastructure.

All construction performed outside the contiguous United States (OCONUS) is also governed by additional mandates that include SOFA, HNFA, and in some instances, BIA. Therefore, the team performing any planning, design, construction, and installation must ensure compliance with the most stringent requirements of any of these agreements that are in place.

3-1.3 Special Considerations.

Special considerations may apply in some locations involving aesthetics, historical preservation, archeological sites, environmental conditions, restricted areas, and wildlife preservation areas. These may include considerations such as use of underground pathways versus aerial; the type of building entrance; mounting of terminals; placement of pedestals; or routing of cables. Consultation is required prior to and throughout planning, design, construction, and installation of all OSP information communications technology infrastructure to ensure all special considerations are captured.

3-2 SPACE REQUIREMENTS.

3-2.1 Types of Outside Plant Supporting Structures.

3-2.2 Cable Vault.

A cable vault (CV) is an enclosed, unmanned information communications technology structure constructed of precast or cast-in-place reinforced concrete, is structurally solid, and installed underground to accommodate cables, splice enclosures, racking systems, low-voltage electronic equipment, lighting, and ventilation. Cable vaults are typically provided at core node and area distribution node (ADN) locations that require copper cable plant distribution to end user buildings (EUB) for voice services and/or support large concentrations of fiber optic cable (FOC). Cable vaults must not be shared with high or low voltage electrical equipment installations other than whatever low voltage equipment is required to support low-voltage electronic equipment and infrastructure within the space.

3-2.2.1 Size.

The cable vault must to future growth of 25 percent. At a minimum, the cable vault must extend the entire length of the main distribution frame (MDF) and have a minimum ceiling height of 7 feet (2.1 meters) above the finished floor (AFF). The cable vault must be designed to provide ample space for installation and splicing of all new and future cabling requirements.

3-2.2.2 Layout.

New cable vaults must be constructed to extend beyond the building's external wall and provide one interior and one exterior personnel entrance with either a ladder or stairs to access the space. Each entrance hatch must be a minimum of 36 inches (914 millimeters) wide by 36 inches (914 millimeters) long to allow rescue personnel to safely enter the confined space in the event of an emergency while using a self-contained breathing apparatus. The interior and exterior walls of the cable vault must be properly sealed and waterproofed to protect the interior space from pests and environmental damage. Protected cage-style industrial lighting must be installed inside the cable vault to provide a minimum horizontal illumination of 50 foot-candles (fc) (500 lux) at 36 inches (914 millimeters) AFF within the space to support routine work operations and the passage of employees in a safe and healthful manner. The cable vault must be provided with adequate ventilation using an exhaust fan with a high-level exhaust stack and a low-level air intake to maintain safe oxygen levels and avoid harmful buildup of combustible gases as defined by the Occupational Safety and Health Administration (OSHA). The cable vault floor must be designed with a constant 1.0% slope elevation to a sump pit equipped with an electric sump pump for the removal of water that may enter the cable vault. The sump pit must be a minimum of 18 inches (457 millimeters) long by 18 inches (457 millimeters) wide by 18 inches (457 millimeters) deep with a grating cover of sufficient strength to support expected loads. The sump pump must be connected to a drainage line and stubbed out through the cable vault wall to the nearest storm drainage structure for sump pump discharge. An SBB must be installed in the cable vault to bond all metallic structures in accordance with the requirements of TIA-758. All vault electrical receptacles must be installed on a ground fault circuit interrupter (GFCI) circuit for the protection of personnel in accordance with NFPA 70®. Cable racking must be installed in the cable vault to support the splice enclosures required to splice the tip cables to the OSP cables. The center of the cable vault is preferred for the installation of cable racking; however, if required, cable racking may also be installed on the cable vault wall. Angled pulling tubes must be placed in the opposite wall in-line with the conduit entrance to facilitate installation of new and future cabling within the cable vault.

3-2.2.3 Maintenance Holes.

MHs are used to facilitate placement and splicing of OSP cables. The MH accommodates cables, splice enclosures, racking systems, and low-voltage electronic equipment. Telecommunications MHs must not be shared with high or low voltage electrical equipment installations other than whatever low voltage equipment is required to support low-voltage electronic equipment and infrastructure within the space. Measurements between MHs are from MH cover to MH cover, center-to-center (C-C), unless otherwise indicated. Measurements from MHs to buildings, pedestals, riser poles, and other structures are from the center of the MH cover to the outside wall, pedestal base, bottom of riser pole (center-to-point).

MHs are either precast or cast-in-place reinforced concrete structures provided with a removable lid that permits internal access to the housed components. All MHs must have an American Association of State Highway and Transportation Officials (AASHTO) working stress design minimum load rating is HS-20 for heavy vehicular traffic. Splayed MHs should be provided at main feed and distribution points where copper cables and high cable counts are planned.

A typical large MH interior size is 12 feet by 6 feet by 7 feet (3.7 meters [length] by 1.8 meters [width] by 2 meters [height]). A typical medium-sized MH is approximately 8 feet by 6 feet by 7 feet (2.4 meters by 1.8 meters by 2 meters). Other sizes and configurations may be used with approval from the COR for contract designs or the Government design lead for in-house designs.

3-2.2.3.1 Maintenance Hole Precast.

The preferred MH structure is precast reinforced concrete. Precast MH types are splayed, non-splayed, or multi-directional with cast-in single or multiple plastic duct terminators to accept the conduits. Splayed MHs are the preferred type when a precast MH structure is used. Suppliers of precast MH structures must have a National Precast Concrete Association (NPCA) certified manufacturing facility that implements and maintains a NPCA certified quality control program. MHs must be H-20 rated for continuous heavy vehicle traffic.

3-2.2.3.2 Maintenance Hole Cast-in-Place.

Cast-in-place MHs may be used where precast structures are not suitable (e.g., overbuild, unique shapes, and limited areas for hole placement). Cast-in-place MH structures must be constructed in accordance with Rural Utilities Service (RUS) Bulletins 1751F-643 and 1751F-644, using Class 1D concrete with high early strength Portland cement consolidated by mechanical vibration. RUS Bulletin 1751F-643,

Table 5, defines the reinforcement bar spacing for each category of structure. If the category of a cast-in-place MH structure is not explicitly stated in the design criteria, the minimum category for the precast MH structure must be 10.0. Conduit window locations and attachment points must be designed so core drilling is eliminated and drilling for anchors is minimized to the greatest extent possible. Drawings for all proposed cast-in-place MH structures must be submitted for approval prior to construction. Drawings must depict the conduit locations, size, and placement of structural reinforcement bars.

3-2.2.4 Hand Holes.

Hand Holes (HH) are reinforced concrete units provided with a removable cover that permits internal access to the housed components. The acceptable pull-point HH size is 4 feet by 4 feet by 4 feet (1.2 meters by 1.2 meters by 1.2 meters) and should be placed only as the last structure before a EUB and where there is no possibility that the conduit system will be extended. The acceptable splice-point HH size is 6 feet by 4 feet by 4 feet (1.8 meters by 1.2 meters by 1.2 meters). HHs with larger dimensions are considered to be MHs. An HH should not be used in place of an MH in a main conduit system. HHs should not contain more than four, 4-inch conduits per wall. Telecommunications HHs must not be shared with high or low voltage electrical equipment installations other than whatever low voltage equipment is required to support low-voltage electronic equipment and infrastructure within the space. All HHs must have an AASHTO working stress design minimum load rating of HS-20 for heavy vehicular traffic, or the Tier 22 rating.

3-3 SUPPORTING STRUCTURE REQUIREMENTS.

3-3.1 Common Installation Practices.

New OSP supporting structures must be installed and placed to support the locations of junction points, offsets, load points, and curvatures within the conduit run. Spacing of OSP supporting structures is determined by the environment (e.g., cantonment or range area); cable type (e.g., copper cables only; fiber optic cables only, or copper and fiber optic cables); number of changes in direction (e.g., bends); cable reel length; proximity to cable origination and termination points; and allowable pulling tension of the cable. Subparagraphs (a) through (k) list a few required common installation practices:

a. Additional MHs or HHs are required once the total number of changes within the planned route exceed 180°.

b. MHs and HHs that contain copper cables of 600 pairs or greater must not be spaced more than 600 feet (180 meters) apart, provided the restriction noted in subparagraph (a) is not exceeded.

c. MHs and HHs that contain both fiber optic and copper cables of less than 600 pairs can be spaced in excess of 600 feet (180 meters), provided the restriction noted in subparagraph (a) is not exceeded.

d. MHs and HHs used as splice points in direct buried applications can be placed as required within the planned route.

e. OSP supporting structures must be installed on a leveled, crushed, washed gravel base of sufficient depth, not less than 6 inches (150 millimeters) in thickness under the entire OSP supporting structure, to allow for proper drainage and stability. The gravel base must extend 1 foot (300 millimeters) beyond the entire perimeter of the OSP supporting structure. Refer to Figure A-19 to show placement of gravel base.

f. Installation of OSP supporting structures must comply with the American Society for Testing and Materials (ASTM) C891-19.

g. Precast concrete supporting structures must be manufactured in accordance with ASTM C858-19.

h. Flowable fill (slurry) must be used to fill in the voids up to the base of the paved areas around all OSP supporting structures. Refer to Figure A-16.

i. In geographical areas with a high-water table, OSP supporting structures must be designed to mitigate the risk of buoyancy (floating) in accordance with the American Concrete Pipe Association (ACPA), *Design Data (DD) 41 - Maintenance Hole Flotation*. Any deviations from these guidelines require approval of the USG. A spreadsheet calculator can be found at https://www.concretepipe.org/wp-content/uploads/2014/09/DD_41-Manhole-Flotation-Analysis.xls to determine if the MH installation is stable with respect to buoyancy. Additional buoyancy design criteria can be found on the NPCA web site at: https://precast.org/wp-content/uploads/2018/11/BuoyancyWhite-Paper2018.pdf.

j. The annular area, which is the space between the walls of the OSP supporting structure and the conduits, must be sealed to prevent infiltration of water, debris, rodents, insects, and other foreign matter.

k. Some OSP supporting structures may require alarm systems to be installed and must be validated with the authorizing official or the PDS owner.

3-3.2 Common Maintenance Hole/Hand Hole Structural Components.

Each new MH/HH must be equipped with an egress frame and cover, grade ring, physical security, exterior attachment hardware (secure and non-secure applications), sump, and interior hardware (e.g., pulling irons, cable racks/hooks). All components must be designed for use within the MH/HH structural space.

3-3.2.1 Egress Frame and Cover.

The MH/HH structure must include a frame and cover to provide a point of egress for maintenance personnel. Egress frame and cover design criteria are defined based upon the area of installation; traffic areas or non-traffic areas. MH/HH structures placed in or near traffic areas must meet the following criteria:

- The frame and cover must be circular and not less than 30 inches (765 millimeters) in diameter and must meet or exceed the AASHTO working stress design minimum load rating of HS-20 for heavy vehicular traffic of the MH/HH structure.
- The cover must fit into a steel frame and, at a minimum, be at grade level, unless otherwise dictated by project installation design.

Oversized frames and covers and/or additional covers may be used for MH/HH structures with special requirements (e.g., supporting structures containing carrier or loading equipment, or supporting structures in congested areas). Steel double hatched cover sidewalk doors are preferred for shallow MH/HH structures with an interior working height of less than six feet (1.8 meters) AFF and placed in non-traffic areas.

3-3.2.2 Grade Rings.

The MH/HH structure must include a grade ring that meets the following minimum design criteria:

- Grade rings must be precast concrete and meet all requirements of ASTM C478/C478M-20. Grade rings must be a minimum of 6 inches (150 millimeters) in height.
- Grade rings must incorporate slots or holes to accommodate 0.75-inch (20-millimeter) diameter frame anchor bolts, unless otherwise specified by the structural engineer.
- When grade ring sections are stacked, grade ring sections must be precisely matched with each other and contain no overhangs to prevent injury to personnel and/or equipment entering or exiting the MH/HH.
- Grade rings installed with cracks or fractures passing through the height of the grade ring, or any continuous crack extending for a length of 3 inches (75 millimeters) or more is unacceptable and will be rejected.
- Grade rings installed with damaged edges which prevent completing a satisfactory joint are unacceptable and will be rejected.
- Installation without a grade ring must be approved by the civil engineer. **Note:** Installation without a grade ring would provide only 10 inches (250 millimeters) of cover (height of egress frame and cover) over the MH.

3-3.2.3 Physical Security.

Lockable cover(s) must be provided for the MH/HH structure when required by the project documentation and/or the site owner. When required, the lockable cover uses a lever and clamp mechanism placed into a receiver installed within the cover. The mechanism should allow the cover to be replaced without indexing the cover to the frame. When in a locked position, the mechanism must be flush with the frame surface, minimizing the potential for the cover to be dislodged. The bolt used to secure the cover must be accessible only by using a special adapter that can be turned only with a socket provided by the manufacturer. The securing bolt design for the cover is available in several different manufacturer's configurations. The desired manufacturer and bolt configuration will be determined by the site owner. A disposable tamper-evident plastic cap that snaps into the locking body mechanism's covering housing the recessed bolt must be installed to help keep dirt and other debris out of the bolt area.

3-3.2.4 Exterior Attachment Hardware.

3-3.2.4.1 Attaching Hardware for Non-Secure Applications.

Two anchoring methods may be used when attaching frames and frames with grade ring(s) to non-secure MH/HH structures:

- Drop-in Anchors: If drop-in anchors are used, each anchor must be a minimum of 0.7 inches (20 millimeters) in diameter. Drop-in anchors must be installed in accordance with the manufacturer's recommendations using the manufacturer's recommended concrete adhesive best suited for the environmental conditions at the installation site. Prior to setting the drop-in anchor, the anchor hole must be brushed and blown out thoroughly to remove all foreign contaminants that could affect proper adhesion.
- Wedge Anchors: Wedge Anchors are acceptable for non-secure applications. When using wedge anchors, the drill bit and anchor diameters are equal. Concrete adhesive cannot be used for wedge anchors, as there is insufficient space between the anchor and concrete for the adhesive to bond.

Anchoring components used for attaching frames and frames with grade ring(s) to non-secure MH/HH structures must satisfy the testing conditions defined in ASTM E488/E488M-18 or equivalent standard. The USG reserves the right to randomly select and test anchoring components for compliance.

3-3.2.4.2 Attaching Hardware for Secure Applications.

Attachment of frames and frames with grade ring(s) to secure MH/HH structures can be accomplished by mechanical methods, non-mechanical methods, or by a combination of both. To attain maximum physical security of the MH/HH structure, a combination of the methods must be used. Levels of security for each method or combination of methods are shown in Table 3-1.

The mechanical method of attachment uses drop-in anchors installed in accordance with the manufacturer's recommendations using the manufacturer's recommended concrete adhesive as described in paragraph 3-3.2.4.1. Additional physical security is attained by replacing the anchors' standard fasteners with tamper-proof fasteners.

The alternative non-mechanical method of attaching frames and frames with grade ring(s) to the MH/HH structure is to use a Type 1, epoxy-resin-base bonding system that satisfies the requirements of ASTM C881/C881M-20a. The epoxy-resin-base bonding system must be applied in accordance with the manufacturer's recommendations and procedures.

Table 3-1 MH/HH Physical Security Levels

Method	Description	Security
1	Mechanical: Tamper proof fasteners	Low
2	Non-mechanical: Type 1 epoxy	Medium
1 & 2	Combination of mechanical and non-mechanical	High

3-3.2.5 Sump.

A sump must be cast into the floor of the MH/HH structure. Design the floor of the MH/HH structure with a constant 1.0% slope to a sump located in the center for the removal and proper drainage of water that may enter the MH/HH. The sump must be a minimum 13-inch by 13-inch (330-millimeter by 330-millimeter) square or a 13-inch (330 millimeter) diameter circle. Either choice must be a minimum of 4 inches (100 millimeters) in depth and covered with a removable grated or perforated cover of sufficient strength to support expected loads.

3-3.2.6 Interior Hardware.

Interior hardware typical for most common MH/HH structure sizes is listed in the Table on Figure A-5. Interior hardware, to include cable pulling irons, cable racks, cable rack supports, and any other interior hardware accessories required, must be corrosion resistant. Size and location of MH/HH structure interior hardware must conform to RUS Bulletin 1751F-643 and RUS Bulletin 1753F-151 to support the weight of the cable(s) and splice case(s). Provide corner racks at the in-line end of the MH/HH structure. A device or method to lock the hooks to the cable rack (step locks) must be provided for all hooks that will be installed to support splice cases.

3-3.3 Water Resistance.

Reasonable efforts must be made to prevent water from infiltrating all OSP supporting structures. At a minimum, apply the following guidelines as long as they do not violate the manufacturer’s recommendations or product warranty.

- Place water-resistant gaskets or seals between the sections of pre-cast OSP supporting structures.
- Place water-resistant gaskets or seals between the cover(s), frame(s), grade ring(s), and OSP supporting structure top(s).

3-3.4 Stenciling.

Stencil new OSP supporting structures inside the structure with an identifier designated by the site owner. Place the stencil near the top of the OSP supporting structure so that it is visible when the cover is open. In addition, conduit windows in both new and reutilized OSP supporting structures must be stenciled (if not already) to denote where conduits are connected.

3-3.5 Grounding.

New supporting structures, regardless of size, must have an integrated ground system, and be clearly identified by the manufacturer, either on drawings or inside the supporting structure. A bonding ribbon must be installed around the interior of each supporting structure so that splice cases and rack anchors can be bonded. Install a bonding ribbon in each half of two-part MHs. Permanently bond the top and bottom ribbons to the integrated ground system.

New splice cases and cases that are reopened and contain conductive elements (e.g., conductors, metallic sheaths, armor, and strength members) must be bonded to the grounding straps system or the existing grounding system. Never open an underground cable sheath for the sole purpose of bonding it to ground.

3-3.5.1 Ground Rod.

For existing underground supporting structures not equipped with an integrated ground system, or older structures requiring supplemental ground rods, ground rods must be steel that is copper-clad and a minimum of 0.75 inches (20 millimeters) in diameter and a minimum of 10 feet (2.75 meters) long. Ground rods must meet requirements and be installed in accordance with NEMA GR 1. Four inches (100 millimeters) of the rod, plus or minus 0.5 inches (13 millimeters), must extend above the finished floor level, if installed in the existing MH. The rod must not enter the supporting structure more than 3 inches (80 millimeters) or less than 2 inches (50 millimeters) from the vertical surface of the adjacent wall. Ground rod electrodes must be permanently and legibly marked with the manufacturer’s identification, and the catalog or equivalent designation within 12 inches (300 millimeters) of the driving end of the ground rod electrode.

3-3.5.2 Ground System Inspection.

Grounding system connections must be verified for mechanical tightness. Tighten loose connections to the manufacturer’s specifications. Inspect grounding electrode system terminations for evidence of corrosion. Clean areas of corrosion and treat with corrosion inhibitor. For in-building grounds, accomplish two-point bonding resistance measurements to verify resistance less than 100 milliohms (0.1Ω) between any two points. For alternating current (AC) and direct current (DC) measurements, amperage measurements should be taken on all accessible grounding electrode conductors to verify less than one AC ampere (1A) and less than five hundred milliamperes (500 mA).

3-3.5.3 Bonding Ribbon.

Bonding ribbon placed around the inside perimeter of the CVs, MHs, and HHs (halos) is not required if they are equipped with an integrated ground system.

3-4 EXTERIOR PATHWAYS.

OSP telecommunications infrastructure projects include several general requirements that must be accomplished prior to the start of any work. These include, but are not limited to, determination of rights-of-way, utility locates, digging permits, traffic closure procedures, crossing obstructions, rock excavation, and unstable soil excavation. These requirements and conditions must be captured, documented, and reviewed with the local government zoning authority to determine proper local procedures.

3-4.1 Utility Easement/Rights-of-Way.

A utility easement/rights-of-way is written permission established to allow aboveground or underground physical infrastructure to be placed along a specific route through a property that belongs to another landowner or federal, state, or local municipality. Some projects may require OSP telecommunications infrastructure to pass through these utility easements/rights-of-way requiring a documented utility easement/rights-of-way to be established. Approval must be established and obtained within a timely manner with the AHJ prior to the start of any work to ensure compliance and to ensure use of new and existing utility easements/rights-of-way is maximized.

3-4.2 Existing Utility Location.

Utility location is the process of identifying and marking existing underground utilities such as telecommunications, electrical distribution, natural gas, storm drainage, water mains, wastewater pipes, and is required to be done prior to the start of any excavation work. The site owner is responsible for the processes and procedures for performing utility locates. Coordination with the Directorate of Public Works (DPW) to ensure strict adherence with these processes and procedures are followed, and to ensure the required lead times to completion are captured. - The utility marking paint must adhere to the American Public Works Association (APWA) Uniform Color Code, be clearly visible, and chalk based not permanent. The utility location marks at the work location must be maintained until the work is completed and they are no longer required.

3-4.3 Existing Utility Verification.

Utility verification is required to positively determine the exact location and depth of the marked utilities and obstructions within the excavation area to avoid damage and safety risks to personnel. The exact location of existing utilities can be determined only by physically seeing the utility. The preferred method for utility verification at each work location must be coordinated with the site owner. Acceptable methods for utility verification are described in paragraphs 3-4.3.1 and 3-4.3.2.

3-4.3.1 Pot holing.

Pot holing is the practice of digging a test hole to provide visual confirmation of underground utilities or obstructions within 24 inches (600 millimeters) of a proposed excavation site to avoid potential damage. When pot holing in road surfaces, the initial hole must be no larger than 12 inches by 12 inches (300 millimeters by 300 millimeters). There are several pot holing methods:

- Hand digging. Hand digging is the safest method of pot holing where digging is accomplished manually with handheld equipment such as a spade shovel.

- Machine digging. Machine digging is the method of digging by mechanical means with heavy equipment such as a backhoe. Powered excavation equipment is not allowed within 24 inches (60 millimeters) of either side of a utility location marking. Clearance restrictions may vary depending on the site owner.

- Vacuum excavation (e.g., slot trenching). Vacuum excavation uses either air or water pressure to break up the soil and a vacuum device to collect the spoils. This technique may be used within congested areas having poorly marked underground utilities and obstructions that cannot be avoided.

3-4.3.2 Ground Penetrating Radar.

Ground penetrating radar (GPR) is a technology that uses radar pulses to image the subsurface area of the earth. This technology can be used to non-destructively locate subsurface objects and structures in various materials such as soil, rock, concrete, asphalt, wood, and water. In historical locations or areas where the existing utility infrastructure is over 35 years old, GPR must be employed to the greatest extent possible to ensure that planned routes are clear of undocumented obstacles.

3-4.4 Digging and Excavation Permits.

Digging and excavation permits complying with all local codes, ordinances, and regulations must be obtained from the site owner prior to starting any excavation and/or construction work. It is highly recommended that all involved parties carefully plan and execute this portion of the project in unison to avoid unexpected problems.

3-4.5 Traffic Closures.

Roadways and parking lots must be closed only for as long as is necessary to complete the project work. Traffic closures must be coordinated with the site safety office. Construction signs, flag personnel, rerouting of traffic, cutting restrictions, and steel plates may be required.

3-4.6 Crossing Obstructions.

3-4.6.1 Paved Surface Crossing.

Pavement crossings must be constructed using one of the following methods: cutting or sawing perpendicularly across the pavement (commonly known as a “T” cut); trenching perpendicularly across the pavement; horizontal directional drilling (HDD) under the pavement; or jack and bore under the pavement.

The preferred method for crossing a paved surface is cutting or sawing perpendicularly across the pavement. When this method is used, concrete encasement is required. The concrete encasement must extend a minimum of 6 feet (1.8 meters) beyond the road bed on each side. If concrete encasement is not practical, then an alternative method that meets the required loading conditions is permitted (e.g., galvanized steel rigid metallic conduit (RMC)). Depending on the location, single step or double step “T” cuts may be required by the site owner. Cutting and restoration of paved crossings must be coordinated with the site owner.

Note: Jack and bore and/or directional drilling must be used only for special circumstances. If additional sections of pipe are required to be welded during the process, local Fire and Safety personnel must be notified.

3-4.6.2 Paved Areas.

OSP supporting structures placed within paved areas must be backfilled with flowable fill (slurry).

3-4.6.3 Range Road Crossing.

For road crossings on installation ranges, concrete encasement must be extended a minimum of 6 feet (1.8 meters) beyond the edges of the road bed on each side. If concrete encasement is not practical, then an alternative method that meets the required loading conditions is permitted (e.g., galvanized steel RMC).

3-4.6.4 Railroad Crossing (Underground).

Push and bore with steel casings is the preferred method for railroad crossings unless otherwise dictated by the commercial railroad owner. Where multiple conduit formations are placed, a minimum of a 12-inch (300-millimeter) diameter steel casing, with a minimum wall thickness of 3/16 inch (5 millimeters) must be used. The casing must extend no less 12 feet (3.7 meters) beyond the centerline of the track or the outermost track if multiple tracks are crossed. The casing must be located no less than 50 inches (1.27 meters) below the top of the rails in accordance with the National Electrical Safety Code® (NESC®). In addition, the casing must be no less than 36 inches (900 millimeters) below the bottom of any crossed drainage ditch adjacent to the railroad bed.

HDD must not be used to place conduits below commercial railroad beds. HDD is not the preferred method of placing conduits below USG railroad beds; however, if HDD is used, the conduit must be placed a minimum of 15 feet (4.6 meters) below the railroad bed in typical soil. The conduit must be placed at such a depth so that standard E-80 live and impact loads of 80,000 lb/ft (119,500 kg/m) must not produce more than five percent deflection in the proposed conduit formation.

3-4.6.5 Pier and Bridge Crossings.

Coordinate design and installation for crossing military, commercial, and privately owned piers and bridges and accomplish in accordance with the requirements and procedures dictated by the state and local bridge authorities, and USG bridge authorities.

Conduit systems installed on all piers or bridges must employ either polyvinyl chloride (PVC) coated steel RMC or red-threaded fiberglass conduit (RTFC), which is the preferred choice. Either conduit type used must be installed using only manufacturer-approved hardware (e.g., hangers).

Place pull boxes at all critical points within the conduit run. Critical points include where the structure has a change in direction, where access for a ship berth is required, and at 90-degree bends. Conduit expansion joints are required at each pier or bridge expansion joint and within approximately 5 feet (1.5 meters) of where the conduit enters a distribution point.

Place expansion joints in the raceway system to coincide with the expansion joints in the structures that are supporting the raceways.

3-4.7 Rock.

Excavate rock from all areas where OSP supporting infrastructure will be placed. Rock excavation is excavation of all hard, compacted, or cemented materials that require use of ripping and excavating equipment larger than defined for common excavation.

Unclassified excavation is excavation of all materials encountered, including rock materials, regardless of their nature or the manner in which they are removed.

3-4.7.1 Classifications.

Refer to the United States Department of Agriculture (USDA) Natural Resources Conservation Service “National Engineering Handbook” Part 631, dated January 2012, for classifications of rock and excavation.

Rock is defined as limestone, sandstone, granite, or similar aggregate found in solid beds or masses in the original or stratified position which can be removed only by continuous drilling, blasting, or use of pneumatic tools. Pavement is not to be considered rock.

Rock which cannot be moved without systematic drilling, blasting, or use of a rock saw includes:

- boulders measuring 0.5 cubic yard (yd^3) (0.382 cubic meter [m^3]) or larger
- other material such as rock in ledges, bedded deposits, un-stratified masses, and conglomerate deposits
- below-grade concrete masonry structures

Table 3-2 Excavation Characteristics of Rock[1]

Classification Elements	Class I	Class II	Class iii
	Very hard ripping to blasting	Hard ripping	Easy ripping
	Rock material requires drilling and explosives or impact procedures for excavation may classify as rock excavation	Rock material requires ripping techniques for excavation may classify as rock excavation	Rock material can be excavated as common material by earth-moving or ripping equipment may classify as common excavation
Head cut erodibility index, k_h [1]	$k_h \geq 100$	$10 < k_h < 100$	$k_h < 10$
Seismic velocity, approximate	> 8,000 ft/s (> 2,450 m/s)	7,000–8,000 ft/s (2,150–2,450 m/s)	(< 7,000 ft/s (< 2,150 m/s)
Minimum equipment size (flywheel power) required to excavate rock. Machines assumed to be heavy-duty, track-type back-hoes or tractors equipped with a single tine, rear-mounted ripper.	260 kW (350 hp), for k_h < 1,000 375 kW (500 hp), for k_h < 10,000 Blasting, for k_h > 10,000	185 kW (250 hp)	110 kW (150 hp)

3-4.7.2 Excavation.

Excavate rock to a minimum of 6 inches (15 millimeters) below the excavation depth required for placement of conduit formation or cable. Prior to placing the conduit or cable, the contractor must backfill the rock excavation and all excess trench excavation with a cushion of sand at least 6 inches deep. Refer to Figure A-23 for additional excavation details.

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[1] **National Engineering Handbook Part 628 Dams**, Chapter 52 Field "Procedure Guide for the Headcut Erodibility Index", Section 52-1, "The head cut erodibility index, k_h, represents a measure of the resistance of the earth material to erosion. The index is the scalar product of the indices for its constituent parameters. The index takes the general form:

$$k_h = M_s \times K_b \times K_d \times J_s$$

Where:

M_s = material strength number of the earth material
K_b = block or particle size number
K_d = discontinuity or interparticle bond shear strength number
J_s = relative ground structure number"

3-4.8 Soil Types.

Soil classification is defined in OSHA Standard 29 CFR 1926 Subpart P, Appendix A. The soil classification system identified in this subpart provides a method of categorizing soil and rock deposits based upon a hierarchy of their stability in decreasing order -- Type A, Type B, and Type C. The categories are determined based on an analysis of the properties and performance characteristics of the soil and rock deposits and the environmental conditions. Type C consists of mostly unstable soil and rock deposits and is considered the most dangerous of the soil types. Unstable soil and rock deposits are defined as soil and rock that by physical characteristics will not stay in place on its own and therefore will require the use of shoring and/or sloping to hold in place. In locations where unstable soil and rock deposits are identified, the unstable soil and rock deposits must be removed to establish a sound base capable of properly supporting the OSP supporting infrastructure.

3-5 SPECIAL CONDITIONS.

Most DoD locations contain areas that may be affected by special conditions. These special conditions must be discussed and documented with the site owner. All procedures from the AHJ must be followed.

3-5.1 Building and Landscape Aesthetics.

Building and landscape aesthetic standards establish an appropriate theme within an area of development without jeopardizing the historical, cultural, and environmental fabric of an installation and its surrounding community. The goal is to maximize the visual and environmental assets and to minimize liabilities, while enhancing the ability of the installation to continue to perform its mission requirements. Assets are visual or natural elements that enhance the image, environmental quality, or sustainability of the installation and must be preserved, enhanced, replicated, and incorporated into the overall OSP supporting infrastructure design. Visual and natural elements include architecture, roads and paths, parking areas, landscape, signage, site furnishings, lighting, utilities, and security. Liabilities are elements or features that detract from the visual image, environmental quality, or sustainability of the installation. Liabilities must be identified so they can be eliminated and avoided. Strict coordination must be accomplished with any local building and installation design requirements and procedures to ensure that visual and environmental assets are incorporated into the OSP, supporting infrastructure design, mitigating liabilities, and preserving the historical, cultural, and environmental character of the installation.

3-5.2 Historical and Cultural Preservation.

Military installations contain an abundance of historical and cultural locations that must be considered when planning for the installation of OSP supporting infrastructure. Historical and cultural locations include historical buildings, structures, objects, districts, landscapes (e.g., battlefields), and archaeological sites that are eligible for or listed in the National Register of Historic Places, as well as sites sacred to federally recognized Native American tribes. During planning, detailed coordination must be conducted with the local historical and cultural resource managers to ensure strict adherence to any local building and installation design requirements and procedures for these locations. Early identification and planning in these locations will help to avoid project delays and additional required funding resulting from inadvertent discovery of historical and cultural resources within the proposed project areas. In addition, any federal, state, and local environmental laws, requirements, and policies must be considered and prioritized throughout this process.

3-5.3 Natural Resource Preservation.

Military installations contain an abundance of natural resources that must also be considered when planning for the installation of OSP supporting infrastructure. Natural resources include threatened and endangered species, wetlands, wildlife preservation areas, forests, undisturbed land, and viewsheds. During planning, detailed coordination must be accomplished with the local natural resource manager to ensure strict adherence to any local installation design requirements and procedures for these locations. Early identification and planning in these locations will help to avoid project delays and additional required funding resulting from inadvertent discovery of impacted natural resources within the proposed project areas. In addition, any federal, state, and local environmental laws, requirements, and policies must be considered and prioritized throughout this process.

3-5.4 Restricted Areas.

Restricted areas on an installation must be avoided during planning and execution of OSP supporting infrastructure installations. Restricted areas include, but are not limited to, areas that contain unexploded ordinance (UXO), hazardous soils, human remains, biological hazards, and landfills. During planning, if it is determined that work within a restricted area cannot be avoided, detailed coordination must accomplished with the site owner to ensure strict adherence to any local installation design requirements and procedures for these locations. In addition, restricted areas of work that contain contaminated soils must comply with the local requirements and procedures for proper removal and disposal of these contaminated soils and/or waste materials. Early identification and planning in locations that contain potential restricted areas will help to avoid project delays and additional funding.

3-6 UNDERGROUND PATHWAYS.

Underground pathways consist of conduit structures used for installation of OSP cable plant between different points of access. Employ practices described this section for design and installation of underground pathways.

3-6.1 Trenching.

Trench width and depth must be determined by the minimum requirements to support the size of the conduit formations, spacing between the conduits, required embedment, and required soil cover. At a minimum, at least 24 inches (600 millimeters) of cover is required above the top of the conduit formation. At least 18 inches (450 millimeters) of cover is required under roads or sidewalks. For conduits installed in solid rock, the cover must consist of at least 6 inches (150 millimeters) of concrete. If rock is encountered below grade, the minimum cover above the concrete-encased conduit must be 12 inches (300 millimeters).

3-6.2 Frost Line.

Movement of underground pathways due to frost heaving can cause damage to OSP cabling. The 50-year frost line data must be used to determine the underground pathway depth requirements. The top of the underground pathway must be buried below the frost line. In areas where frost lines exist at excessive depths, determine the minimum depth requirements to support local frost line requirements.

3-6.3 Shoring and Benching.

The contractor must rigorously adhere to the OSHA, host nation, and local requirements for shoring or sloping. For CONUS projects, the contractor must follow the safety and trenching requirements in 29 CFR 1926, Subpart P. The contractor must follow the specification of Appendix B, 29 CFR 1926, Subpart P. The trench width for conduit must be wide enough to permit tamping of dirt on the sides of the conduit formation.

Excavations over 5 feet (1.5 meters) deep that a person must enter or work within must have walls shored or benched as approved by a competent person meeting the requirements of 29 CFR 1926, Subpart P.

3-6.4 Hand Digging.

Hand digging must be accomplished in all locations around all MHs, HHs, building entrance points, utility crossings, under curbs, and any other obstacles identified by the site owner.

3-6.5 Plowing.

Plowing must be used only in range environments or other areas where there are no significant obstacles and where cable runs typically exceed 1,000 feet (305 meters) between supporting structures. Plowing paths must be within designated zones that are based on specified distances from the centerline of the road. The zone width is based on minimum and maximum setback distances from the centerline of the road. Designated zones and setback distance criteria must be coordinated with the site owner.

3-6.6 Horizontal Directional Drilling.

HDD is a trenchless utility installation method for installing underground conduit that involves using a directional drilling machine to accurately drill along the chosen bore path and back ream the required conduit. The vertical profile of the bore alignment is typically in the shape of an inverted arc.

3-6.6.1 Methodology.

HDD is a multi-stage process that consists of drilling a pilot hole along a predetermined path and then pulling the desired conduit product back through the drilled space. Back reaming must be used when it is necessary to enlarge the pilot bore hole.

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 a slurry that acts as a stabilizer of the surrounding soil, preventing bore hole collapses and loss of lubrication.

3-6.6.2 Drilling Fluids.

Use a mixture of bentonite clay and fresh clean potable water of the proper phosphate (pH) level as the cutting and soil stabilization fluid. Viscosity must vary to best fit soil conditions. No other chemicals are to be used in the drilling fluid without written consent of the USG and after a determination is made that the chemical additives are environmentally safe. When drilling in suspected contaminated ground, the drilling fluid must be tested for contamination and disposed of appropriately in accordance with applicable federal, state, and local environmental regulations.

3-6.6.3 Pits.

Sump areas must be created at the drill entrance and exit locations to contain any escaping free-flowing slurry (drilling fluids) at the ground surface that might damage or be hazardous to the surrounding work area. Excavation for entry, recovery pits, slurry sump pits, or any other purpose must be accomplished in accordance with UFGS 31 23 00.00 20.

3-6.6.4 Tracking.

A method of locating and tracking the drill head during the pilot bore must be employed during the drilling process. Conduit must be installed so that conduit location can be readily determined by electronic designation after installation is complete. For non-conductive installations, this must be accomplished by attaching a continuous conductive material, such as a copper wire line or coated conductive tape, externally, internally, or integrally with the product.

3-6.6.5 Conduit Requirements.

Conduit materials for HDD must meet or exceed the standards defined in Table 3-2.

Table 3-3 Conduit Standards for Directional Boring

Material Type	Standard	Title
High-density polyethylene (HDPE)	ASTM D2239	Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
High-density polyethylene (HDPE) (SDR)	ASTM D3485	Standard Specification for Coilable High Density Polyethylene (HDPE) Cable in Conduit (CIC)
High-density polyethylene (HDPE)	ASTM F1962	Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings
High-density polyethylene (HDPE)	ASTM F2160	F2160 Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD)

HDPE conduit must be manufactured for inside diameter control (manufactured based on the specified inside diameter). Four-inch (100-millimeter) HDPE conduit must have a minimum wall thickness standard internal dimension ratio (SIDR) of 11.5. When connecting HDPE conduits, the internal diameter of the adjoining HDPE conduits must be within 0.030 inches (0.75 millimeters). PVC conduit that uses mechanical-type connectors made for the purpose of horizontal directional drilling may be used in lieu of HDPE, with USG approval. All conduit used for HDD must be placed within soil-tight joints. Joint requirements are defined in paragraph 3.6.8.3.

3-6.6.6 Restrictions.

The HDD trenchless utility installation method may be used only in locations approved by the site owner. Conduits installed under roads by means of HDD must be of sufficient depth to clear existing utilities and meet the H-20 load ratings. The conduits placed by HDD must not directly enter an MH, but must be attached to conduit stub-outs that extend a minimum of 10 feet (3 meters) from the MH. The maximum radius curvature of a bore is limited to the maximum conduit diameter multiplied by 100 feet per inch (30.5 meters per 25 millimeters).

3-6.6.7 Environmental Restoration.

The work location must be restored to the pre-construction condition after installation is complete. The work location must be cleaned of all excess slurry or spoils and properly disposed of in accordance with applicable federal, state, and local environmental regulations as the conduit is introduced. Excavated areas must be restored in accordance with UFGS 31 23 00.00 20. Damage caused by heaving, settling, escaping drilling fluid (fracout), or the HDD operation to roads, parking lots, pavement, curbs, sidewalks, driveways, lawns, storm drains, landscapes, and other facilities must be restored by the installer performing the work.

3-6.7 Jack and Bore.

Jack and bore (auger boring) is a trenchless utility installation method where a horizontal auger is driven through a jacked steel casing into the soil. The steel casing is advanced simultaneously with the boring operation using a hydraulic jacking system. Jack and bore must be accomplished in accordance with UFGS 33 05 23 and conform to the following criteria:

- Materials. Galvanized RSC must be fabricated from weldable quality steel. Steel pipe casings must comply with Grade B requirements of ASTM A139/A139M-16 or ASTM A252/A252M-19.
- Grout. Conduits placed through casing pipe must be grouted with non-shrinking cement grout. Grout must conform to ASTM C1107/C1107M-20.
- Conduit Spacers. Plastic spacers must provide at least 1 inch (25 millimeters) of spacing between conduits as necessary to allow encasement material to fully surround each conduit. Use of bricks or wood as spacers is not permitted. Placement between spacers must be no greater than five feet (1.5 meters). Use bands to secure bore spacers and conduits together. Banding must follow the best practices of the latest issuance of NEMA TCB 2-2017.
- Steel Casing Size. Sizing of casing is determined by the total diameter of the conduit formation. See Table 3-3 for casing sizing guidelines per 4-inch (100-millimeter) conduit formation.

Table 3-4 Casing Size per Four-inch (100-milimeter) Conduit Formation

Casing Size	Wall Thickness inches (millimeters)		Inside Diameter inches (millimeters)			Number of conduits
	Protected	Non-protected	Protected	Non-protected	Measured	
14	0.219 (5.6)	0.311 (7.9)	13.562 (344.5)	13.376 (339.75)	O.D.	4
16	0.219 (5.6)	0.312 (7.9)	15.562 (395.3)	15.376 (390.55)	O.D.	5
18	0.281 (7.1)	0.344 (8.7)	17.500 (444.5)	17.312 (439.73)	O.D.	7
22	0.344 (8.7)	0.375 (9.5)	21.376 (542.9)	21.250 (539.75)	O.D.	9
30	0.438 (11.1)	0.469 (11.9)	29.188 (741.38)	29.062 (738.17)	O.D.	16

3-6.8 Conduit.

3-6.8.1 Types.

Underground pathways consist of conduit structures built using the following acceptable conduit types:

- rigid nonmetallic conduit Schedule 40 – for direct burial or encasement in concrete. Must meet the requirements of NEMA TC-2-2020
- rigid nonmetallic conduit Schedule 80 – for direct burial or encasement in concrete. Must meet the requirements of NEMA TC-2-2020
- metallic pedestal disconnect (MPD) – for direct burial or installation in conduit
- RMC – for direct burial or encasement in concrete
- intermediate metallic conduit (IMC) – for direct burial or encasement in concrete
- RTRC and fittings – for direct burial or encasement in concrete
- innerduct PE – for direct burial or installation in conduit
- innerduct PVC – for direct burial or installation in conduit
- microduct for air blown fiber (ABF) applications
- HDPE – for plowing and HDD

3-6.8.2 Innerduct/Textile Innerduct.

For underground installation, new fiber optic cable plant must be installed in either an innerduct, subduct, or textile fabric mesh solution. More than one fiber optic cable may occupy a multi-cell textile fabric mesh solution. When existing underground pathway conduits systems are reutilized, determine the preferred solution for the location in which the installation is being completed. Fiber optic cables must never be installed directly into a 4-inch (100-millimeter) duct.

3-6.8.3 Joints.

Conduits must be joined to be soil tight. Joints must form a sufficiently smooth interior surface between joining sections so that cables are not damaged during pulling. Joints between dissimilar types of conduits (e.g., PVC, HDPE) must use appropriate connectors designed to provide a seal between the conduit types and prevent damage to cables pulled through these joints. These joint connections must be rated at a minimum of 125 pounds per square inch (psi) (0.862 megapascal (MPa)). Prepare joint surfaces in accordance with the manufacturer's recommended practices. HDPE to HDPE connections can be made by heating using one of the following techniques: socket, butt, electrofusion, or mechanical coupling.

Accomplish heat fusion in accordance with procedures detailed in ASTM F2620 and the procedures established by the manufacturer of the equipment being used. Prior to installing and joining HDPE conduits with an internal diameter of greater than 3 inches (75 millimeters), the conduit must be re-rounded and all inner edges beveled.

3-6.8.3.1 Socket Fusion.

This technique requires use of specially-designed hot irons to simultaneously heat both the external surface of the pipe and the internal surface of the socket coupling. Socket fusion is designed for outside diameter controlled standard dimensional ratio (SDR) material. Although this fusion joining method does not create a bead on the inside of the conduit created by the fusion process, telecommunications application requires internal diameter controlled or SIDR material. If socket fusion fittings are available for SIDR conduit, this method will be acceptable for joining HDPE together. Fabricate socket fusion joints in accordance with the latest issuance of ASTM F2620.

3-6.8.3.2 Butt Fusion.

This technique uses specially developed machines that secure, face, and precisely align the PE conduit for the flat face hot iron fusion process.

The butt fusion process produces an internal bead of equal or larger size than the visible outer bead. This method is acceptable only if verification can be provided that either the internal bead will have a negligible impact on the cable installation, or it can be demonstrated that the internal bead can be removed and the conduit will successfully pass a mandrel test. Fabricate butt fusion joints in accordance with the latest issuance of ASTM F2620.

Electrofusion differs from the hot iron (socket) fusion method described in (a). The main difference is the method used to apply heat. Electrofusion employs a special electrofusion fitting with an embedded wire coil. Electrofusion coupling must be accomplished in accordance with the procedures established by the manufacturer of the equipment being used.

3-6.8.3.3 Mechanical Coupling.

There are various coupling devices available to connect conduits of like material and for conduits of differing materials. Mechanical joints may be entirely mechanical, or a combination of mechanical and heat fusion or solvent weld. Mechanical couplers must meet or exceed the minimum pressure rating of 125 psi (862 kPa) and provide a smooth transition to prevent damage to cables pulled through this type of joint. The coupling must be encased within concrete in all mechanically joined conduits.

Accomplish heat fusion in accordance with procedures detailed in ASTM F2620 and the procedures established by the manufacturer of the equipment being used. Prior to installing and joining HDPE conduits with an internal diameter of greater than 3 inches (75 millimeters), the conduit must be re-rounded and all inner edges beveled.

3-6.8.4 Bends and Sweeps.

No more than the equivalent of two 90 degree bends (180 degrees total) may be used between pull points, including offsets and kicks with a curvature radius of less than 100 feet (30 meters). Avoid back-to-back 90 degree bends. The following definitions apply:

- 90 degree bend: Any radius bend in a piece of conduit that changes the direction of the conduit by 90 degrees.
- Kick: A bend in a piece of conduit, usually less than 45 degrees, made to change the direction of the conduit.
- Offset: Two bends usually having the same degree of bend, made to avoid an obstruction blocking the run of the conduit.
- 90 degree sweep: A bend that exceeds the manufacturer's standard size 90 degree bend (e.g., 24 inches (600 millimeters) is standard for a 4-inch (100-millimeter) conduit).
- Back-to-back 90 degree bend: Any two 90 degree bends placed closer together than 10 feet (3 meters) in a conduit run.

Use radius-manufactured bends to the maximum extent possible. Manufactured bends may be used on lateral conduits at the riser pole or building entrance. RTSC bends and sweeps may be used where there is a potential to burn through the conduit during cable pulling. Where a conduit enters a building and sweeps up through the floor's slab, galvanized RSC must be used. Bends and sweeps must be concrete-encased to protect the conduit from the pressures developed while pulling cables.

3-6.8.5 Minimum Formation Sizing.

The orientation of the conduit arrangements must maintain integrity throughout the entire run. Determine the number and size of conduits within the pathway based on the number of cables, cable diameter, known future growth, and sparing. Follow cable manufacturer conduit sizing charts or recommendations, if available. Conduit formations include:

- Node conduits: Conduits between a core node and the first MH should be based upon the types of services, the size of cables, the number of outside cables (not just limited to FOC), and 100% future growth.
- Main conduits: A main conduit run includes the MHs and conduits from the first MH away from the node and in locations where the cable routes diverge into multiple directions providing the pathways for large feeder cables and/or core FOCs.
- Lateral conduits: Lateral conduits run from the sidewall of an MH to the supporting structure (HHs, cross-net cabinets, pedestals, poles).
- Subsidiary conduits: Subsidiary conduits extend from the end wall of an MH, run along the main conduit run for some distance, and then turn to feed a structure.

- Entrance conduits: Entrance conduits run from an MH, HH, or pole to the EUB.

Sizing requirements include:

- one four-inch (100 millimeter) conduit for every four-way two-inch (50 millimeter) conduit system
- a minimal conduit size of 2 inches (50 millimeters) for pathways between supporting structures and end-user facilities
- for large copper cables, conduit with a diameter at least 1.15 times greater than the diameter of the cable, or one-half trade size larger in diameter than the diameter of the cable to be installed

3-6.8.6 Spacing.

Spacers are required for all conduit formations (both encased and non-encased) to properly support the conduits and maintain their integrity of orientation and must be installed in accordance with the manufacturer’s specifications. Plastic spacers must provide a minimum of 2 inches (50 millimeters) of spacing between conduits, with the only exception being where conduits are placed in rock, a minimum of 1 inch (25 millimeters) of spacing will be acceptable. Use of bricks or wood as spacers is not permitted. However, use of concrete cinder blocks as spacers (and tie-downs) is an acceptable alternative with the approval of the COR. Conduits and spacers must be securely banded together. Spacers must be installed at a minimum of one spacer every 5 feet (1.5 meters). Direct buried conduit formations must be installed with embedment material around and between the conduits.

3-6.8.7 Placement.

Sweep down new conduits and install in the lowest available conduit positions within the MH or CV. In node and main conduit runs, install new conduit formations at a depth where a duct formation of equal size could be placed above the existing formation while maintaining 24 inches of cover or below the frost line, whichever is greater. New lateral, subsidiary, and entrance conduit runs must allow for 24 inches of cover or be below the frost line, whichever is greater. New conduits must not prevent placement of future conduits in the upper conduit positions. Conduits must terminate in bell ends or conduit terminators at the point of entrance into the MHs and HHs to assist in pulling cable. Main conduits entering cast-in-place or precast MHs must be located in the lower portion of the end wall. Conduits leaving side walls must be located a minimum of 4 inches (100 millimeters) from the end walls located farthest from the central office or serving node. Clearances of 12 inches (300 millimeters) must be maintained between main conduit formations and the roofs or floors of MHs. Unless the construction drawings indicate otherwise, wall recesses must be provided at conduit entrances. Locate lateral conduits leaving the MH to provide clearances of 4 inches (100 millimeters) from roofs and adjacent walls.

Conduits entering the walls of the supporting structure must be perpendicular to the face of the exterior wall. Conduits must remain perpendicular for a minimum 5 feet (1.5 meters) away from the exterior wall.

3-6.8.7.1 Stub-outs.

Stub-outs are short pieces of conduit that extend beyond the wall of a building or supporting structure offering an interface for future expansion. Stub-outs must be capped at the soil end and plugged and tagged within the building or supporting structure. Stub-outs for buildings with under-slab entrances must be RMC (refer to Figure A-11). Stub-outs must extend past the wall at least 5 feet (1.5 meters).

3-6.8.7.2 Transition.

For conduits transitioning from the lower conduit window of an MH to the nominal trench depth, the transition must be accomplished in no less than 30 linear feet (9.1 meters) from the MH to reduce the radius of the bends.

3-6.8.7.3 Clearances.

Clearances of 12 inches (300 millimeters) must be maintained between conduit formations and the roofs or floors of the supporting structure. Subsidiary conduits entering MHs must be located to provide clearances of 4 inches (100 millimeters) from roofs and adjacent walls.

3-6.8.7.4 Maintenance Holes.

Conduits entering the end wall of an MH must be located in the lowest portion available and remain together. Alternatively, the contractor may divide the conduit window of a multidirectional MH in half, leaving the other half of the window for future conduit systems. Highest conduits in the formations are reserved for fiber. The contractor must present the conduit pattern and identify conduit locations to the COR for approval prior to construction.

3-6.8.7.5 Existing Conduits.

New conduits installed with an existing conduit system must be placed above the existing conduit formation if the minimum depth requirements can be maintained. If sufficient cover is not available to maintain the depth requirement, the new conduit must be placed beside the existing conduit formation.

3-6.8.7.6 Rerouting of Existing Conduits.

Existing conduits must be joined to new MHs (pre-cast or cast-in-place) by rerouting the designated conduits from the demolished or abandoned MH to the new MH. Rerouting must begin , at least 30 feet (9 meters) from the old MH to allow for standard bending radii and pulling tension. Continuity of operations on the affected cables must be maintained during the conduit rerouting actions.

3-6.8.7.7 Conduit Termination.

Conduits must terminate in bell ends or conduit terminators at the point of entrance into supporting structures (MHs, HHs, cable vaults and buildings).

3-6.8.8 Concrete Encasement.

3-6.8.8.1 Vehicle Traffic.

Nonmetallic conduits placed under paved roads by open cut must be protected by concrete-encasement. In addition, conduits placed under paved road surfaces and certain heavy traffic non-surfaced roads must be protected by one of the following methods: concrete-encased conduit; galvanized RSC; steel pipe casings; or HDD of HDPE conduits.

3-6.8.8.2 Concrete Type.

The concrete type must be a wet type mix and be placed to ensure the concrete completely surrounds all conduits. Concrete used to encase conduits must have a minimum compressive strength of 3,000 psi (20,700 kPa). Additional concrete mix requirements may be required by the local jurisdiction and will be furnished by COR. Portland type cement must conform to American Society for Testing and Materials ASTM C94/C94M. Flowable fill must not be used as a substitute for concrete encasement.

3-6.8.8.3 Encasement Requirements.

Concrete must flow around and encase all conduits. The top of the concrete encasement must be a uniform finish and must be consolidated by mechanical vibration to ensure no air or voids are trapped in the mix. Provide a minimum 3 inches (75 millimeters) on each side and top, and 1.5 inches (38 millimeters) between the bottom row of conduit and the trench bottom.

a. New conduit systems must be connected to all supporting structures with dowels (those with or without conduit windows). Refer to Figure A-17.

b. For existing supporting structures, both precast and cast in place, that require core drilling, reinforcement bars must be placed 3 inches (75 millimeters) away from the outside wall and tied to dowels. Secure dowels to supporting structure using ASTM C881-rated epoxy. Refer to FigureA-17.

c. For conduits that will be encased in concrete, the contractor must tie down the conduits to minimize movement during the placement of concrete. The conduits in a concrete-encased pathway must be tied down at least every 10 feet (3 meters) using an industry-recognized method such as metal rods/stakes and strapping. The metal rods must be a minimum of 1/4 inch (6 millimeters) thick. As an alternative, the contractor may use concrete cinder blocks as both spacers and tie downs, with approval from the COR.

d. Concrete forms must be used when encasing conduits to OSP supporting structures to limit blockage of empty conduit knock-outs or windows in the OSP supporting structure.

e. The contractor must contact the on-site USG representative of the time and location prior to pouring any concrete over the conduit formations. The onsite USG representative will inspect the spacers and tie-downs prior to encasing the conduit formation.

f. Concrete encasement of the conduits for a “core path” is required where no alternate paths are present. All conduits between core buildings and serving MHs must be concrete encased.

g. Concrete encasement must be used in stream/drainage areas subject to washing out; in major construction zones; and for all sweeps or bends.

h. New encasement must be doweled to the existing encasement.

3-6.9 Detection and Marking of Underground Pathways.

3-6.9.1 Warning Signs.

3-6.9.1.1 Cantonment Areas.

Warning signs or route markers must be placed along the cable route to denote the location of below ground building entrances, changes in cable route, and in congested utility crossing locations. The signage or route marker must be permanent.

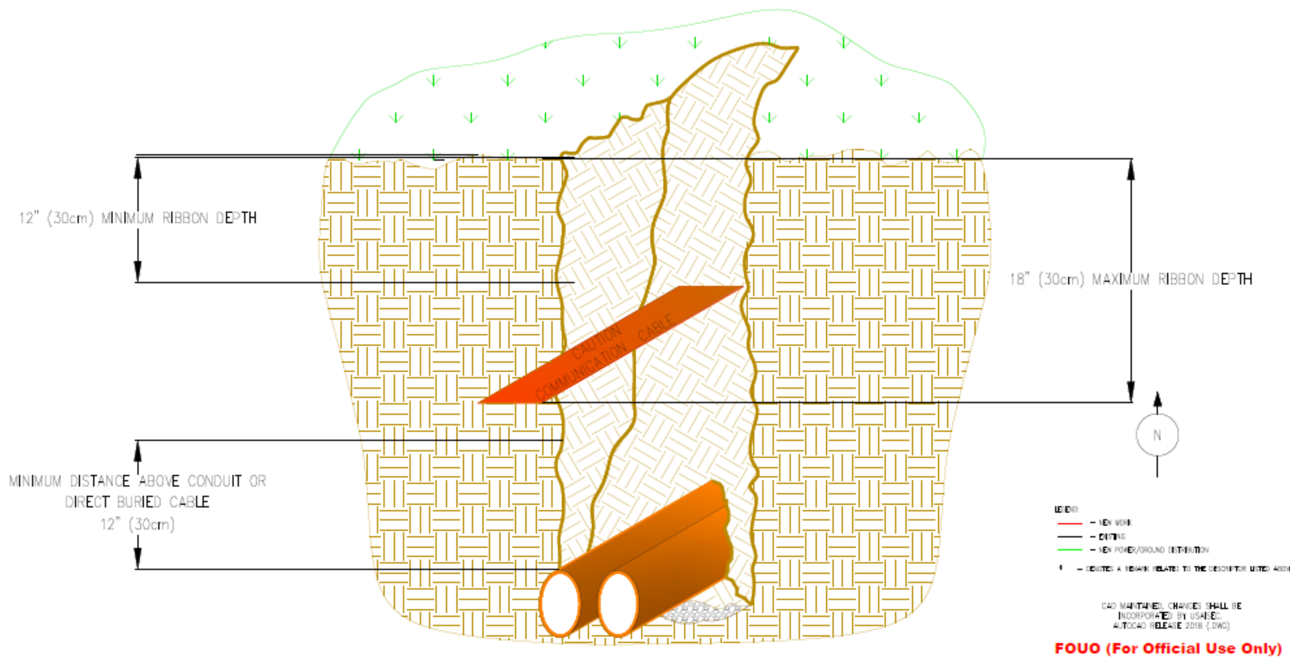
3-6.9.1.2 Non-Cantonment Areas.

Warning signs or route markers must be placed along the cable route at intervals of no greater than every 250 feet (75 meters), at each change in route, on both sides of each street crossing, over pipelines, and over buried power lines. The warning signs or route markers must be color-coded and orange in color.

3-6.9.2 Warning Tape.

Warning tape must meet the requirements of the latest version of UFGS 31 00 00. Warning tape must be installed at least 12 inches (300 millimeters) below the surface level and maintain a minimum separation of 6 inches (150 millimeters) between the warning tape and non-metallic conduit formations and DB cable installations (Figure 3.1). Warning tape must not exceed the manufacturer’s recommended depth below grade. For DB cable and non-metallic conduit formations placed by plowing, the warning tape should not be wider than the plow.

Figure 3-1 Warning Tape Placement



3-6.9.3 Detection Wire for Direct Buried Cable.

Detection wire for DB cable must be a minimum of #12 AWG insulated, single strand, solid copper wire, coated with a minimum 30-mil PE jacket designed specifically for buried use. Splices within the detection wire must be connected using a compression-type connector to ensure continuity. Wire nuts must not be used. After installation, the detection wire must be tested to verify end-to-end continuity and submitted in a report to the USG.

3-6.9.4 Detection Wire for Conduit Formations.

Detection wire must be installed within all new conduit formations. One detection wire must be installed per conduit formation. The detection wire must be placed as centrically as possible within the top of the conduit formation. When dielectric cable is installed in existing conduit formations that do not contain toneable cables, a detection wire must be installed along with the dielectric cable. Detection wire must be terminated on a terminal block and placed either within the MH near the opening, or in a “test well” so that the detection wire can be accessed without physically entering the MH confined space. Each detection wire and termination must be labeled to indicate the path of the detection wire (e.g., “TO MH-3”). Splices in the detection wire must be connected using a compression-type connector to ensure continuity. Wire nuts must not be used. After installation, the detection wire must be tested to verify end-to-end continuity and submitted in a report to the USG. No detection wires are required when the conduit formation contains an integrated detection wire (e.g., toneable conduit/textile innerduct).

3-6.9.5 Conduit Embedment.

Embedment is not required when the conduit formation is concrete-encased. Non-concrete encased conduit formations must be backfilled in accordance with NEMA TC2 and UFGS 31-00-00, using whichever is more stringent. Backing terminology includes:

- Bedding and initial backfill zone. The embedment zone of a conduit trench is that portion of the trench from approximately four inches (100 millimeters) below the bottom of the first row of conduits to approximately six inches (150 millimeters) above the top of the final row of conduits.

The external loading capacity of flexible conduits largely depends upon the type of embedment material chosen and the quality of the installation of the material in the embedment zone.

- Embedment material. The best materials for use in the embedment zone are coarse-grained materials such as crushed stone, sand, and pea gravel. Coarse-grained soils mixed with silts or clays can also be satisfactory, provided the mix is compactible and stable. Soils not recommended in the embedment zone are the highly organic materials and the highly plastic clays. The maximum particle size in the embedment zone should be limited to one inch (25 millimeters) in diameter.

- Final backfill zone. The final backfill zone of the conduit trench is that portion of the trench extending from the top of the embedment zone to the top of the trench.

- Final backfill materials. The final backfill is not critical for conduit performance, but can be important for providing a proper foundation for a road or other structure which may be constructed over the conduit trench. Selection of the final backfill materials is not critical for the conduit; all types of soils are acceptable, provided they do not contain particles that can damage the conduit. For conduit systems that will be under roads or parking lots, flowable fill is the preferred material.

3-6.9.6 Backfilling.

All excavated areas around new OSP supporting structures, conduits, and/or cables must be backfilled in accordance with the latest issuance of UFC 3-220-04FA.

Prior to placing any embedment or backfill, the pathway must be inspected by the onsite USG representative to verify the acceptability of the new supporting structures, pathway, and cables. In accordance with UFGS-31 00 00, all excavated areas around the new supporting structures, conduits, bore pits, and cables must be backfilled with approved materials.

3-6.9.6.1 Materials.

Material larger than 1 cubic foot (0.028 cubic meters) is not allowed in the backfill and must be removed. Materials must be free from hydrocarbons and other chemical contaminates. Approved materials can be a mixture of earth to include loam, sandy clay, sand, gravel, and soft shale. Backfill materials must be placed into the excavation and then tamped in 1-foot (300-millimeter) layers.

If native soil is of a suitable type, it may be used as embedment and backfill material. Blasted rock, large boulders, broken concrete, or pavement must not be used a backfill materials. Final backfill is a topsoil used that is conducive to growth of plants and grass. Material larger than 1 inch (25 millimeters) in diameter is not allowed in the final backfill.

3-6.9.7 Flowable Fill (Slurry).

Flowable fill, also known as slurry, must used for backfilling the portion of the trench above concrete-encased conduit systems under roads and parking lots. The flowable fill must meet the compressive strength requirements defined in Military Detail (MIL-DTL)-32537, and placed using the traditional (wet) method. Flowable fill must not be used as a substitute for concrete encasement. Backfilling the portion of the trench above concrete-encased conduit systems under roads and parking lots with clean backfill is acceptable only when approved by the COR. Reference paragraphs 3-6.9.6 and 3-6.10 for backfill and restoration requirements.

3-6.10 Restoration.

Restore disturbed areas to the same density, grade, and vegetation as adjacent undisturbed material. Grade the earth to a reasonable uniformity. Resurface paved areas with the same type of material and to the same thickness as the original surface. Paved surfaces must be restored in accordance with UFC 3-270-01. Restore road surface markings, including but not limited, to yellow lines, white lines, cross walks, and parking lot stripes, to the original location and condition. Clean the work site of debris and restore it to original condition.

3-6.11 Proof, Rod, and Clean Conduits.

Proof new conduits and existing vacant pathways prior to use. Proofing must be witnessed by the USG representative. Conduit with existing cable or that will not allow the passage of a mandrel must be rodded and cleaned.

3-6.11.1 Rodding.

Rodding entails inserting or pushing a rod through the conduit to determine the length, locate the other end, determine if the conduit is usable, and insert a pull string.

3-6.11.2 Cleaning.

When necessary, clean conduits using high pressure jetting, wire brushes, rubber conduit swabs, and leather washer conduit cleaners.

3-6.11.3 Proofing.

Proofing a conduit consists of pulling a test mandrel or slug through the duct to ensure the integrity and alignment of the ducts. New ducts in main and subsidiary duct runs must be mandrelled with a test mandrel (non-flexible) or slug that is approximately 12 inches (300 millimeters) in length and 0.25 inches (6 millimeters) less than the duct inside diameter. Use the test mandrel to verify the integrity of duct joints, to test for out-of-round duct, and to verify that sweeps are not so severe as to preclude placement of multiple cables or large diameter cables. A 6-inch (150-millimeter) length test mandrel may be used to test duct runs to buildings or riser poles. Pull the mandrel through all conduits to ensure proper alignment. Pulling the test mandrels through the conduits should be accomplished after backfilling, but prior to replacing any grass, sod, or repaving.

3-6.12 Pull String/Rope/Tape.

Place a pull string, pull rope, or pull tape, rated at not less than 200-pound (890-newton) tensile strength within each new conduit and innerduct. Provide a minimum of 5 feet (1.5 meters) of slack at each end of the conduit, tied and secured to the back of the conduit plug to prevent being accidently pulled back into the conduit. When installing new cable in existing conduit, place and secure a pull string, pull rope, or pull tape alongside the new cable so it cannot be accidently pulled back into the conduit.

3-6.13 Subdividing Conduit.

Subdividing conduit is the practice of using either innerduct or fabric-mesh to facilitate the initial and subsequent placement of multiple cables within a single conduit space.

The preferred count for fabric mesh in a 4-inch (100-millimeter) conduit is two, where each has three cells. Cut off fabric mesh at the end of each conduit run, leaving a minimum of 2 feet (600 millimeters) of spare slack. Roll up the spare slack and place it back inside the end of the conduit. Subdivision requirements of conduit can differ at each B/P/C/S and must be coordinated prior to installation with the AHJ.

3-6.14 Conduit Sealing.

3-6.14.1 Vacant New Conduit.

Seal new vacant conduits, multi-ducts, and innerducts using a mechanical reusable conduit plugs at each end. Conduit plugs must have a means of attaching pull strings. Cap stub-outs at the soil end, and plug and tag them within the building or OSP supporting structure.

3-6.14.2 Existing Occupied Conduit.

After placing new cables in existing conduit, seal the pathway at both ends. Sealant must be designed for use within telecommunication applications to block entry of water and debris and be removable without damage to the conduits or cables. Install sealant in accordance with the manufacturer recommendations and procedures. When using expandable foam, encapsulate only the first 6 inches (100 millimeters) of conduit by placing removable materials within the conduit to block any unnecessary expansion of the foam.

3-6.15 Conduit Rehabilitation.

The preferred method of installing new cables uses existing pathways. Rehabilitation of existing conduits is an alternative to installation of new conduit when the cost, location, or magnitude of new construction is prohibitive. Conduits intended as candidates must be surveyed to ensure that rehabilitation is feasible. The survey must include an inspection from the MH/HH or building entrance endpoints, either visually or by a conduit video system, from both ends of the conduit. If a pathway is found blocked or damaged, coordinate with the COR to discuss an acceptable solution. Collapsed or crushed conduit must not be used for rehabilitation. Several acceptable methods of rehabilitating conduit have been found, which include, but are not limited to, split conduit repair, resin-impregnated tube, conduit clamps, or conduit replacement. Accomplish conduit rehabilitation in accordance with the latest issuance of ASTM F1216, using ASTM-compliant products and processes. Completed rehabilitated conduit must be inspected by a conduit video system to verify it was restored to a usable system that meets the minimum requirements defined within this UFC.

3-7 DIRECT BURIED INSTALLATION.

DB is a type of installation where the infrastructure is in direct contact with the soil, without extra protection from the elements. DB solutions are implemented via trenching or plowing. Install DB cable in accordance with the latest issuance of RUS Bulletins 1751F-640, 641, and 642. Refer to Figure A-10 for typical pedestal measurements for DB.

3-7.1 Cable Type.

Rodent-protected (armored) cable must be used for DB applications.

3-7.2 Direct Buried Fiber Optic Cable.

DB FOC must be placed at a depth providing a minimum top cover of 48 inches (1200 millimeters) or below the frost line, whichever is greater. In solid rock, the minimum top cover must be 6 inches (150 millimeters).

3-7.3 Direct Buried Copper.

DB copper cable must be placed at a depth providing a minimum top cover of 24 inches (600 millimeters) in soil, 36 inches (900 millimeters) at ditch crossings, and 6 inches (150 millimeters) in solid rock (RUS Bulletin 1753-150/RUS Form 515A).

3-8 AERIAL INSTALLATION.

Aerial cable plant systems are not preferred. However, exceptions may include range cables or other long runs through undeveloped areas, locations where underground systems cannot be installed (e.g., wetlands), or locations where compliance with local mandates are required and require site owner approval. The desired or required reliability (99.999 percent) of some communications systems may preclude use of aerial pathways. Supporting documentation for aerial placement is available in RUS Bulletin 1751F-630 and 1751F-635.

3-8.1 Aerial Fiber.

Do not use aerial fiber splices without USG approval. Place fiber optic splices in a pedestal at the bottom of the pole. The cable alone must not support the aerial splice case. Fiber splice locations must include enough cable slack to allow the splice case to be moved into a splice trailer or tent for maintenance or service. Secure the cable slack to the existing messenger. Organize slack on aerial FOCs neatly, using aerial fiber optic storage loops ("snowshoes"). Base the snowshoe's size on the cable bend radius.

3-8.2 Aerial Copper.

Support all terminals and splice cases by direct attachment to the messenger strand, pole, building, or pedestal. The cable alone must not be used for support. Use pole-mounted and fixed-count terminals and place them so that no single drop exceeds 500 feet (150 meters) in length.

3-8.3 Messenger Strand.

The smallest messenger strand used for all new installations must be 6.6M. A 2.2M strand should be used only as an extension of existing 2.2M strands. FOC must be installed on its own messenger. Do not lash copper and fiber cables on the same messenger without site owner approval. A figure-eight type cable may be used; however, no additional cable must be lashed to it.

3-8.4 Guys and Anchors.

Place new guys and/or anchors for each new messenger strand at each applicable location (cable turns, wind loading, cable ends). The down guy must be sized to the next larger strand. Permission may be required to use an existing anchor.

3-8.5 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. Slant conduit sleeves placed through the entrance wall downward towards the outside a minimum of 0.5 inch (13 millimeters). Waterproof all building entrance points.

3-8.6 Horizontal Clearances for Poles/Aerial Cable.

Adhere to horizontal clearance standards in accordance with the latest issuance of the NESC®.

3-8.7 Vertical Clearances for Aerial Cable.

Communications cables must be no closer to power cables than 40 inches (1,000 millimeters) at the pole. At midspan, communication cables must be no closer than 75 percent of the separation distance at the pole. Adhere to vertical clearance standards in accordance with the latest issuance of the NESC®.

3-8.8 Aerial Cable Slack.

Slack on aerial cables must be neatly organized, using aerial fiber optic storage loops ("snowshoes"). Base the snowshoe's size on the cable bend radius. Calculate the minimum amount of slack as follows:

- road crossings (aerial): 100 feet (30.5 meters)
- aerial per linear mile: three locations, each with 100 feet (30.5 meters)

3-9 EXTERIOR OUTSIDE PLANT CABLING.

Install cable plant to avoid kinks and other sheath deformities. Cables must be rated in accordance with the latest requirements of the National Electrical Code (NFPA 70®) for the environment in which they will be installed.

3-9.1 Cable Pulling Tension.

When pulling cable into ducts, inner ducts, or sub-ducts, do not exceed the manufacturer's recommended pulling tension. Use of properly rated breakaway swivels is recommended. Various commercial cable lubricants compatible with different types of cable sheathing materials are available for pulling cables. During installation, a cable lubricant should be used in the proper amount specified by the lubricant manufacturer. Environmental conditions such as temperature can affect the overall performance of the pulling lubricant and must be conveyed to the manufacturer when making the proper selection. Pulling must comply with all manufacturer's recommendations.

3-9.2 Evaluating Existing Cable Plant.

When installation includes work on existing cable plant (e.g., copper cable and fiber optic cable) that is to be re-used, test all affected pairs and/or strands before performing any splice work or cable throws. Test results must be compiled, to include any defective pairs and/or strands identified, and submitted to the COR to be addressed by the USG prior to proceeding with installation.

3-9.3 Cable Transfers, Cuts, and Throws.

Cable transfers, cuts, and throws must maximize use of existing resources. Cables and terminals affected by cable count transfers must be retagged in the field to reflect all new changes. Coordinate cable transfers, cuts, and throws with the site owner.

3-9.4 Service Loops.

For supporting structures with fiber optic splice cases, install a 75-foot (25-meter) splice loop on each side of the fiber optic splice case. In addition, 75-foot (25-meter) service loops are required at the last MH prior to building entrances. The service loop should be properly labeled and securely supported by two cable hooks. Position cable hooks so the highest one supports the underside of the top of the coil and the bottom hook supports the underside of the bottom of the coil.

3-9.5 Copper Cable.

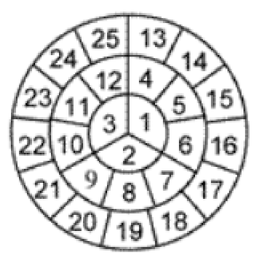
Copper cabling in outside plant implementation is diminishing rapidly with fiber centric backbones, but smaller copper counts may still be needed for legacy systems. Size all copper cables to provide a minimum of six copper pairs to each building.

3-9.5.1 North American Telephone Copper Cable Specifications.

North American telephone copper cable must be UL-listed and meet the specifications of Telcordia, GR-421-CORE. The conductors within the copper cable must be color coded using a basic color coding scheme to provide different color combinations on the insulation of each cable pair. The North American standard is based on a 25-pair binder group (see Figure 3-2) defined by Telcordia, GR-421-CORE, with the following colors:

- Tip: white (pairs 1-5), red (pairs 6-10), black (pairs 11-15), yellow (pairs 16-20), violet (pairs 21-25)
- Ring: blue (pairs 1, 6, 11, 16, 21), orange (pairs 2, 7, 12, 17, 22), green (pairs 3, 8, 13, 18, 23), brown (pairs 4, 9, 14, 19, 24), grey (pairs 5, 10, 15, 20, 25)

Figure 3-2 GR-421-CORE, 25 Pair Binder Group Structure



25 Pair

3-9.5.2 European Telephone Copper Cable Specifications.

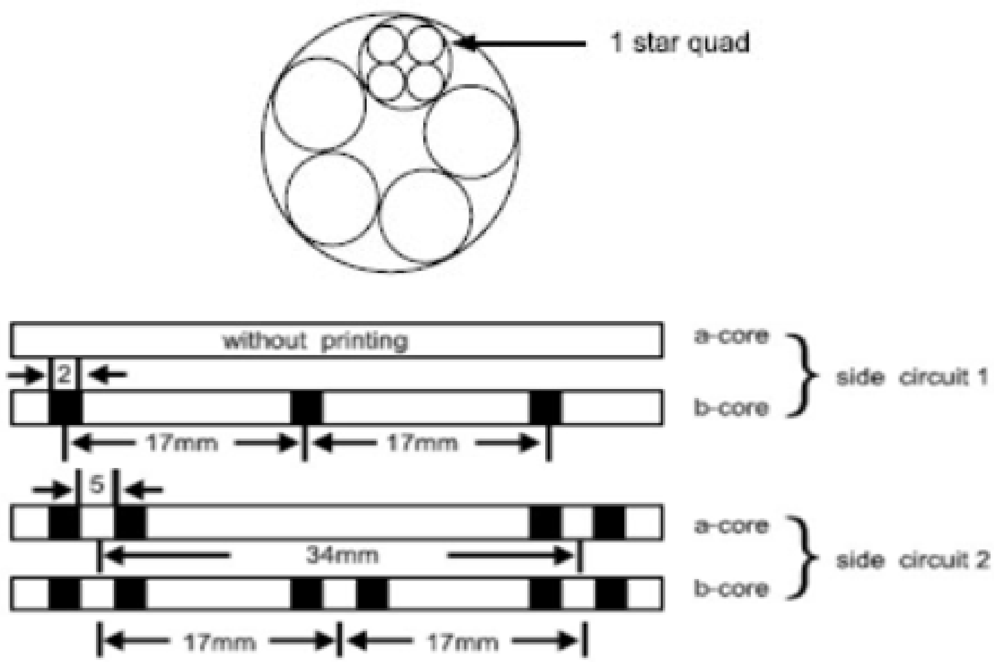
European telephone copper cable must meet the specifications of DIN VDE 0815/A1:1988-05 and DIN VDE 0816-1:1988-02. Commercially available, industry standard cables must be type A-02YSOF (L) 2Y …x2x0.6 ST III BD. The ellipsis (…) represents the required pair count. The conductors within the copper cable must be color-coded using a basic color-coding scheme to provide different color combinations on the insulation of each cable pair. The European standard is based on a 10-pair (five star-quads) sub-unit (Figure 3-3) defined by DIN VDE 0816-1:1988-02 with the following characteristics:

- Each star-quad of the sub-unit is defined by a unique insulation color. The first star-quad is red, the second star-quad is green, the third star-quad is grey, the fourth star-quad is yellow, and the fifth star-quad is white.
- The first or pilot sub-unit is marked by an open helix of red plastic tape.
- Remaining sub-units are marked with open helix of white or transparent plastic tape.
- Insulation of single conductors within a star-quad is marked with black rings.

3-9.5.3 Gauge and Resistance.

The cable gauge (copper conductor size) must be #24 American Wire Gauge (AWG) in North America and 0.6 millimeters in Europe.

Figure 3-3 DIN VDE 0816-1:1988-02, 10 Pair Sub-Unit Structure



3-9.5.4 Loading.

Analog telephone sets or circuits must not exceed 18,000 feet (5,490 meters) unless approved by the USG. If approved, these telephone sets or circuits must be loaded. When loading copper cables, use H88, loading 3,000 feet (914 meters) from the telephone switch or digital loop carrier for the first load (includes calculations for tip cables, jumper wires,) and every 6,000 feet (1,830 meters) thereafter. End sections, to include all drops and station wire, must be greater than 3,000 feet (914 meters) and less than 12,000 feet (3,660 meters). Proprietary digital or Integrated Services Digital Network (ISDN) telephone sets used with the telephone switch must not be loaded. Design build-out capacitors on trunk circuits for placement between telephone switches and load points shorter than 6,000 feet (1,830 meters) or between loads and end sections. Cable pairs used for data circuits must not be loaded.

3-9.5.5 Splicing.

Splice copper cable in accordance with the latest issuance of RUS Bulletin 1753F-401. Splice cable as one continuous length using one of two common modular splicing techniques: the inline or the fold-back technique. The inline technique places the conductor in a straight-across arrangement, providing for little slack within the conductor. The fold-back technique allows the conductors to be folded into the splice, facilitating future work within the splice. The fold-back technique is preferred. Completed splices must meet performance and mechanical specifications similar to those for a single copper cable of the same overall length.

3-9.5.5.1 Connectors and Caps.

Use self-piercing, electrical, filled connectors when plastic-insulated conductors are spliced. Connectors must be placed and installed using a tool specifically designed to place them. In North America, a 25-pair splicing module 3M-type MS2, or equivalent, must be used. In Europe, a 10-pair splicing module must be used. The same modules must be used throughout each project and must be consistent with previously installed connectors to preclude the requirement for a variety of installation tools. The integrity of all binder groups within the splice must be maintained. All dead pairs in a copper cable must be spliced through if the size of the continuing cable allows a clear and cap at the end. Use only UL-listed material for capping cable pairs.

3-9.5.5.2 Splice Cases.

Use encapsulant-fillable closures on underground and buried splice cases and fill with encapsulant upon the completion of the splice(s) in accordance with RUS Bulletin 345-72. Use of non-encapsulated, re-enterable splice cases in aerial or underground non-pressurized networks is permitted for non-direct buried applications. Do not install splice cases allowing their weight to be supported by the cables on the cable hooks in the MH. Installed splice cases must not interfere with ingress and egress into the OSP supporting structure space for technicians entering to perform maintenance. The preferred method for installing splice cases is to hang them from an overhead support structure (e.g., pipe supported by a set of cable hooks above the splice case). Do not place splice cases near or on the floor of the OSP supporting structure. To ensure continuity, bond new splice cases, existing splice cases that are reopened, and their associated components that contain conductive elements (e.g., conductors, metallic sheaths, armor) to the grounding electrode system of the OSP supporting structure in accordance with the requirements of this UFC.

3-9.5.6 Bend Radius.

The minimum bend radius for non-gopher-resistant OSP twisted-pair cable during installation must not be less than ten times the cable diameter, and after installation must not be less than eight times the cable diameter, as specified in ANSI/TIA-758.

The minimum bend radius for gopher-resistant OSP twisted-pair cable during installation must not be less than fifteen times the cable diameter, and after installation must not be less than ten times the cable diameter, as specified in ANSI/TIA-758. If the manufacturer's recommended installation and post installation bend radius requirements are more stringent, then follow the manufacturer's specifications.

3-9.5.7 Count Assignment.

When assigning new copper cable counts, the center of the cable must be the last pairs assigned on a cable route. The higher pair counts within the cable must be used first. The highest pair count in the cable must be located nearest to the telephone switch, and the lowest pair count must be farthest away. Per the requirements of 6-pair and/or 12-pair terminals, Pair 13 (of a binder group) rather than Pair 1 must be spared. If existing cable plant is reused and the cable pair count assignment differs from this layout, coordinate updated cable count assignments with the site owner.

3-9.5.8 Building Terminations.

3-9.5.8.1 Protected Entrance Terminal.

A PET is a device that provides electrical protection and a demarcation termination point where the OSP cabling transitions to the inside plant (ISP) cabling within an EUB.

PETs must be UL-listed and must be of flame-retardant construction and equipped with a build-in splice chamber; either 5-pin solid state or gas protector modules; locking cover; and output onto either 110 blocks or RJ21 connectors. PETs used for European projects must be equipped with protected, line-sharing adapter plus (LSA+) terminal blocks. Connect PETs to the building's lightning protection grounding system as required in NFPA 780. Terminate OSP copper cable pairs on the primary protector blocks of the PET, equipped with either 5-pin solid state or gas protector modules.

3-9.5.8.2 Main Distribution Frame.

The MDF serves as the intermediate interface between the OSP cable and the telephone switch cables at core node and ADN locations. The iron framework of the MDF supports the horizontal blocks and vertical connectors. Equip the MDF with guard rails and end rails. When re-using an existing MDF, install additional horizontal blocks and/or new vertical connector sections to support new cable plant if none are available. A minimum of 36 inches (900 millimeters) of clearance around the guard and end rails of the MDF is required for safety.

a. Horizontal Blocks. The horizontal blocks are mounted on the horizontal side of the MDF and terminate the telephone switch cables between the telephone switch and the MDF. The type and number of horizontal blocks on the frame are based upon the telephone switch solution and must be determined prior to installation. Stencil horizontal blocks to show the termination identification information.

b. Vertical Connectors. Vertical connector blocks are mounted on the vertical side of the MDF. Each vertical protector block must protect either 100 or 200 OSP cable pairs. Equip each vertical connector block with tip cables that are pre-terminated. The tip cables are routed either 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 plant. Provide connectors for the tip cables as either stub-up or stub-down, as required by the type of installation. Vertical connectors protect the electronics within the telephone switch room by providing lightning and surge protection. Each termination corresponds to a pair of the OSP cables. All OSP cable pairs must be terminated on connectors. Stencil each vertical connector block to show the cable number and the pair counts for all connectors on that particular vertical connector block. Connectors must show the count terminated. A schematic of the vertical side of the MDF is shown in Figure A-11. Use space-saver type MDF connectors unless directed otherwise by the USG.

c. Cross-Connects. Install cross-connects 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 or other analog circuit. Leave approximately 8 inches (200 millimeters) of slack in the cross-connect wire to allow re-termination for future moves, additions, or changes.

d. Special Circuits. Special circuits, such as data circuits, T-1s, or alarms, are non-switched and must be treated differently than voice circuits. Various colors of protector modules are available to help with differentiation. Coordinate the specific color and marking for each special circuit type with the site owner. Cross-connect special circuits to designated blocks on the horizontal side and not to telephone switch horizontal blocks that provide telephone numbers.

3-9.5.9 Acceptance Testing.

Conduct end-to-end testing to ensure every cable pair installed, spliced, and terminated is installed in accordance with applicable USG and industry standards. Complete end-to-end tests in accordance with RUS Bulletin 1753F-201, IEEE Standard 743-1995, and other applicable documents referenced within. End-to-end tests that must be completed, include, but are not limited to, the following:

- direct current (DC) insulation resistance
- short/crosses
- grounds
- opens
- reversals
- splits
- transpositions
- shield continuity
- loop resistance

- insertion loss
- capacitance

Document and compile test results into an official test report format, to include raw data files, for submission to the USG. One hundred percent (100%) of all pairs within a cable must past initial acceptance testing prior to installation. After installation, 99 percent (99%) of all cable pairs must pass final acceptance testing unless the failed percentage of defective cable pairs are deemed by the USG not economical to recover. All defective cable pairs must be identified by their location and the type of fault(s). Any faults caused by defective cable pair splices must be corrected.

Existing copper cable being rehomed and re-terminated must be tested end-to-end following the testing protocols in this section for new cable to recertify the newly completed permanent link. If existing cable pairs are damaged during rehoming and re-termination, they must be properly repaired.

3-9.6 Fiber Optic Cable.

3-9.6.1 Cable Types.

There are two types of fiber optic cable used in OSP; single-mode (SM), and multi-mode (MM). New OSP fiber optic cable must be SM; however, designers may use MM to mate with existing plant in coordination with all stakeholders. Loose tube cable construction is better suited for the OSP environment. Tight-buffered cables are not recommended for use above the frost line except to edge devices that may not readily accept loose tube connections because they may be subject to damage from freezing water or moisture.

3-9.6.1.1 Multi-mode Fiber Optic Cable.

Fiber strands must have a nominal core/cladding diameter of 50/125 microns. All cabled MM fibers must have the characteristics in Table 3-6 over the entire specified temperature range.

Table 3-5 Multi-mode Dual-Windowed Fiber Optic Cable Characteristics

Function	Parameters for 50 Microns	Parameters for 62.5 Microns LEGACY ONLY
Core/cladding diameter (microns)	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)

Function	Parameters for 50 Microns	Parameters for 62.5 Microns LEGACY ONLY
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)**	
*Building/breakout cables (tight buffer). Minimum bandwidths do not apply to tight buffered or breakout type cables. Minimum bandwidths for tight-buffered cable are 400 MHz-km at both 850 nm and 1,300 nm. The index of refraction profile of MM fiber must 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

3-9.6.1.2 Single-mode Fiber Optic Cable.

Use SM FOC as defined in ANSI/TIA-568, TIA-758, and International Telecommunication Union-Telecommunication Standardization Sector (ITU-T) G.652 through ITU-T G.657 documents. All cabled SM fibers must have a maximum attenuation value of 0.5 dB/km for high grade at 1,310 nanommeters over the entire specified temperature range.

Table 3-6 Single-mode Dual-Windowed Fiber Optic Cable Characteristics

Function	Parameters
Maximum attenuation dB/km @ 1,310 nm	0.5*
Maximum attenuation dB/km @ 1,550 nm	0.4*
Zero dispersion range	1,310 nm (+/- 10)
Maximum dispersion range	3.2 ps/nm-km (range 1,285 to 1,330 nm) 19 ps/nm-km (range 1,550 nm)

Function	Parameters
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)
*Building/breakout cables (tight buffer). Minimum attenuations do not apply to tight-buffered or breakout type cables. The maximum attenuation for tight-buffered cable is 1.00 dB/km @ 1,310 nm and 1.0 dB/km @ 1,550 nm. **Building/breakout cables (tight buffer). Tensile load rating and minimum bending radius do not apply to tight-buffered breakout-type cables.	

ps=picosecond

3-9.6.1.3 Non-zero Dispersion-shifted Fiber.

Fiber optic cables installed to high bandwidth optical transport equipment (e.g., Dense Wave Division Multiplexing (DWDM), Optical Transport Node (OTN), PON) must employ non-zero dispersion-shifted fiber (NZDSF) FOC when cable distances exceed 25 miles (40 kilometers). NZDSF FOC must meet or exceed the recommendations of ITU-T Recommendation G.655, Table 1/G.655.C and Table 2/G.655.D. Table 3-6 presents an extract from the ITU-T G.655 recommendation. If use of standard fiber versus NZDSF for the distance is in question, determine which fiber optic cable type will support the channel capacity for the distance at which the cable will be installed.

Table 3-7 Non-zero Dispersion-shifted Fiber Single-mode Fiber Optic Cable Characteristics

Fiber Attributes		
Attribute	**Detail**	**Value**
Mode field diameter	Wavelength	1,550 nm
	Range of nominal values	8-11 µm
	Tolerance	+/- 0.7 µm
	Number of turns	100
	Maximum at 1,625 nm	0.50 dB
Chromatic dispersion coefficient wavelength range: 1,530-1,565 nm	λ_{min} and λ_{max}	1,510 nm and 1,565 nm
	Minimum value of D_{min}	1.0 ps/nm-km
	Minimum value of D_{max}	10.0 ps/nm-km
	Sign	positive or negative
	D_{max} - D_{min}*	≤ 5.0 ps/nm-km*
	Maximum PMD_Q	0.20 ps/ √ km

λ=wavelength; µm=micrometer; D=chromatic dispersion coefficient; M=cable sections

3-9.6.2 Bend Radius.

The minimum bend radius for FOC during and after installation must conform to the latest issuance of ANSI/TIA-568. If the manufacturer's requirements are more stringent, follow the manufacturer's installation practices.

3-9.6.3 Cable Count.

Assign new fiber optic cable strand counts in a similar manner to copper counts. Drop the highest number strands within the cable count first; Strand 1 will be the farthest from the serving core node or ADN. Fiber counts must be split, handled, and/or terminated in groups or bundles of 12 strands. Drop groups or bundles designated as spares (dark fibers) in the nearest OSP supporting structure (e.g., MH, HH, or cable vault) stipulated by the site owner to position them for future growth. If the existing cable plant is reused and the strand count assignment differs from this layout, coordinate the updated strand count assignments with the site owner.

3-9.6.4 Splicing.

Fiber optic cable splicing permanently joins two fiber strands together and must be accomplished in accordance with TIA 609A000. There are two fiber splicing methods: mechanical splicing and fusion splicing. Mechanical splicing doesn't physically fuse two optical fibers together; rather, two fibers are held end-to-end mechanically. In fusion splicing, two fiber strands are fused together with an electric arc. Use the fusion method when splicing FOC into one continuous length. Fusion splices must have an insertion loss of <0.05 dB and return loss of >55 dB for loose tube fiber, or must have an insertion loss of <0.10 dB and return loss of >55 dB for ribbon fiber. FOC splice cases must meet requirements of TIA/EIA 515B000 and be tested using the manufacturer's recommended testing procedures to validate the integrity of the splice case seal. FOC splice cases must be installed within OSP supporting structures (e.g., MH, HH, or cable vault) in accordance with RUS Bulletin 1751F-642. Direct-buried splices may be used only in emergency situations (restoration of communications) and must be locatable through the installation of a permanent in-ground marker. Loop-through splicing must be used in lieu of dedicated cables (home runs) to the serving location. In loop-through splicing, only the fiber strands branching off from the main cable run to enter an EUB are cut and spliced, and the remaining fiber strands are not. The remaining fiber strands are folded back within the splice case and routed on to the next branch point. Binder group integrity must be maintained during this process. Splice unused spare fibers (dark fibers) through if the size of the FOC allows for the installation of a clear and cap at the end. Prepare unused spare fibers (dark fibers) for future splicing requirements. All splicing must be fusion spliced except for instances of emergency restoration when fusion splicing is not available.

3-9.6.5 Building Terminations.

3-9.6.5.1 Devices.

Strands of OSP FOC plant entering an EUB, ADN, or core node from an exterior pathway must be properly terminated within each facility on fiber optic patch panels (FOPP). Extend the OSP fiber optic cabling from the building's entrance facility to the main telecommunications room in accordance with NFPA 70® requirements. The main telecommunications room will house the FOPPs and serve as the facilities demarcation point where the OSP cabling transitions to ISP cabling. All FOPPs must be stenciled with the panel number, cable identification, and cable count.

3-9.6.5.2 Methods.

Accomplish new FOC terminations using the physical contact (PC) family of small form fit connectors and adapters. PC connectors and adapters, also referred to as polished connectors, are designed to support network devices with connection rates of 10 Gbps or higher. PC connectors and adapters that can be used include ultra PC (UPC), super PC (SPC), and angle PC (APC). APC connectors are typically used in video and RF signal transport where UPC are more suited for data networks. Use duplex LC connectors for new installation. If existing FOC plant and FOPPs are being reworked, subscriber connector (SC) or straight tip (ST) (ST™ compatible) connectors and adapters may be used to mate to existing plant with the approval of the site owner. All connectors and adapters must meet the requirements defined in TIA 604. OSP FOC strands must be fusion spliced to factory produced and compatible pigtails for FOPP termination.

3-9.7 Design Criteria.

The DoD currently employs a number of architectural topologies for OSP at each B/P/C/S. The intent is to provide voice and data services at the lowest possible cost, to include the total cost of ownership. Each B/P/C/S and project-specific criterion must be individually analyzed to determine the best technical solution based on available funding. One of the most important guiding principles for design and implementation of OSP infrastructure is to ensure single points of failure that would impact the user populace are eliminated in accordance with the Uniform Capabilities Requirements (UCR).

Paragraph 3-9.7.1 provides minimum criteria when specific guidance is not provided in project documentation.

3-9.7.1 New Cable Installation Minimum Requirements.

If the design requires installation of new cable, the requirements in Table 3-8 apply to all buildings unless the facility is designated as a special case. Special case buildings must meet the minimum requirements defined in Table 3.9.

Table 3-8 Standard Fiber Cable Sizing Between Buildings

From	To	Minimum Existing Fiber Strands	Minimum Fiber Strands if Installing New Cable	Notes
Core node	Core node	144	288	1, 2, 4
Server farm IPN/ISN	Core node	72	144	1, 2, 4
ADN	ADN/ core node	72	144	1, 2, 4
ADN	EUB	12	12	3, 5

IPN=Installation Processing Node; ISN=Installation Servicing Node; ADN=Area Distribution Node; EUB=End User Building

Notes:
1. The physical path of the cable from a physical ADN location to each adjacent core node/ADN should be direct to the connected core node/ADN without routing through or patching through any other building, with the exception of stand-alone cable huts or vaults.
2. The physical pathway between building locations must be dual-homed where two connections are run over two physically diverse paths or over a single concrete encased path.
3. Single physical pathway between building locations where a single connection is established.
4. Designs for new FOC must include at least 25-percent spare, unused strands, with cables designed in multiples of 12-strand groups.
5. Designs for new FOC must include at least 50-percent spare, unused strands, with cables designed in multiples of 12-strand groups.

Table 3-9 Special Case Fiber Cable Sizing between Buildings

COMMAND AND CONTROL USERS	
User Classification	**Description**
Special C2 users	• President of the United States of America • Secretary of Defense • Chairman of the Joint Chiefs of Staff • Commanders of the united commands • RED Switch subscribers

COMMAND AND CONTROL USERS	
User Classification	**Description**
C2 users	• Users that have the requirement for C2 communication, but do not meet the criteria of special C2 users. • Includes any person (regardless of position in the chain of command) who issues guidance or orders that direct, control, or coordinate any military forces, regardless of the nature of the military mission, whether said guidance or order is issued or effected during peace or war time.
Other Users	• Do not meet the criteria for special C2 users and C2 users. • May also be denied access during national emergencies.

Note: User classifications pertain to Defense Switched Network (DSN) access. Originally defined and applied to voice services, their use has been extended to data services by implication.

Table 3-10 Infrastructure Requirements for Buildings Requiring Connections to Multiple Nodes

User Classification	Building Entrance Requirements	Standards Document
Special C2 users	Diverse dual entrance facilities with a minimum separation of 20 feet (6 meters)[1] Entrance conduits at a minimum will be concrete encased.	NFPA 1221, 8.4.3.2[2] Specific requirements defined as the mission dictates Requirements listed here are the absolute minimum for design purposes.
C2 users	Diverse dual entrance facilities with a minimum separation of 20 feet (6 meters)[1]	NFPA 1221, 8.4.3.2[2] Requirements listed here are the absolute minimum for design purposes.
Main data facilities	Diverse entrance facilities with a minimum separation of 66 feet (20meters) The building entrance or the serving conduits will be below ground.	NFPA 1221, 8.4.3.2[2] Latest issuance of ANSI/TIA 942 ANSI TIA/942 does not state if the entrance facility is above or below ground.

User Classification	Building Entrance Requirements	Standards Document
Hospitals	Diverse dual entrance facilities with a minimum separation of 20 feet (6 meters)[1] The building entrance or the serving conduits will be below ground.	NFPA 1221, 8.4.3.2[2] NFPA 99
Emergency Operation Centers	Diverse dual entrance facilities with a minimum separation of 20 feet (6 meters)[1] The building entrance or the serving conduits will be below ground.	NFPA 1221, 8.4.3.2[2]
Fire stations (as mission dictates)	Diverse dual entrance facilities with a minimum separation of 20 feet (6 meters)[1] The building entrance or the serving conduits will be below ground.	NFPA 1221, 8.4.3.2[2]
Garrison headquarters	Diverse dual entrance facilities with a minimum separation of 20 feet (6 meters)[1] The building entrance or the serving conduits will be below ground.	NFPA 1221, 8.4.3.2[2]
Military Police (if not co-located with EOC)	Diverse dual entrance facilities with a minimum separation of 20 feet (6 meters)[1] The building entrance or the serving conduits will be below ground.	NFPA 1221, 8.4.3.2[2]

[1]Minimum separation is the same minimum separation for medical facilities.
[2]NFPA 1221, 8.4.3.2: Where multiple communications centers that serve a jurisdiction are not located in a common facility, at least two circuits with diverse routes, arranged so that no singular incident interrupts both routes, must be provided between communications centers.

Note 1: Non-concrete encased underground conduits and direct buried cables are considered diverse if the minimum separation between them is greater than 20 feet (66 meters).

Note 2: Except for Special C2 uses, node connections can share the same conduit system if the shared pathway is concrete-encased.

3-9.7.2 Passive Optical Networks in the Outside Plant Architecture.

The designer must obtain approval from the technical authority before designing a PON architecture. The way in which a PON influences the OSP design depends on whether the PON solution serves an individual building, multiple buildings, or an entire campus. PON is a point to multi-point architecture where signals from the headend or central office are divided by a passive optical splitter and fed downstream to many end users. In a single building PON solution the feeder fiber from the central node would traverse through the MH and duct system and the splitter would typically be located in the building. A PON serving multiple buildings or an entire campus would involve placing a splitter or series of splitters in the OSP section of the architecture (e.g., MH, HH, enclosure).

3-9.7.3 Air Blown Fiber in the Outside Plant Architecture.

ABF systems are an alternative to traditional optical fiber and innerduct solutions. ABF systems push FOC through preinstalled micro-ducts or tubes utilizing compressed air. ABF systems can be useful in scenarios where frequent moves, adds, and changes to the infrastructure are necessary or where it is not realistic to break ground to install new OSP infrastructure (e.g., airports, runways, training campuses). It is important to note that ABF systems often require proprietary equipment such as blowers, micro-ducts/tubes, fiber cable, and manufacturer’s accessories. The maximum distance most vendors will support without advanced blowing techniques is just over a half mile (3280 feet or 1 kilometer). The designer must obtain approval from the technical authority before implementing an ABF system. All blown fibers must be installed in new or existing micro-duct and manufacturers couplers must be used as required.

3-9.7.3.1 Fiber Optic Cable Testing.

Testing must be completed on all FOCs (OSP cable, premise distribution, patch cords), cable connections, splices, and terminations. Test using Tier 1 and Tier 2 test equipment, or a combination of both. Both a light source and power meter (LSPM) and optical loss test set (OLTS) are used for Tier 1 testing. An OTDR is used for Tier 2 testing. Tier 1 and Tier 2 testing must be accomplished in accordance with ANSI/TIA-568 and TIA-526 Series, SM fiber optic cable must be tested at wavelengths 1310 nanometers and 1550 nanometers for both Tier 1 and 2 testing. MM fiber optic cable must be tested at wavelengths 850 nanometers and 1300 nanometers for both Tier 1 and 2 testing. All connectors and bulkheads must be thoroughly cleaned prior to performing any testing. The following tests must be done at minimum for each tier:

- Tier 1 Testing:
  - Optical power
  - Optical loss (insertion loss) single reference jumper
- Tier 2 Testing:
  - Unidirectional (pre-installation)
  - Bidirectional (post-installation) with minimum 0.63 mile (1 kilometer) long launch and receive cables.

– Fiber characterization (chromatic dispersion (CD), polarization mode dispersion (PMD))

a. For new fiber optic cable installations, end-to-end testing using Tier 1 and Tier 2 test equipment must be performed on every fiber strand installed, spliced and/or terminated as follows. Prior to installation, Tier 2 testing (unidirectional) must be performed on all strands per bundle of new fiber optic cable while the cable is still on the manufactures cable reel. This test will verify the cable functionality is free from defects or damage from the manufacturer before installation. Factory test results are not acceptable, as damage may have occurred during shipment to the project location. Any fiber optic cable strands that fail pre-installation testing must be documented and reported to the USG prior to moving forward with installation.

b. Following completion of fiber optic cable installation, to include permanent placement, splicing and connector termination, both Tier 1 and Tier 2 (bidirectional) testing must be performed on all new strands per bundle of fiber optic cable.

c. For existing fiber optic cable that is being rehomed and reterminated, Tier 2 testing (unidirectional) must be performed from the originating or unaffected end prior to the start of work to identify existing defects or anomalies that need to be corrected. Once work has been completed on the existing fiber optic cable as part of the rehoming/retermination effort, Tier 1 testing must be completed from the end of the new work completed. Upon completion of Tier 1 testing, Tier 2 testing (bidirectional) must be completed to recertify the completed permanent link. Any existing fiber optic cable strands damaged during the rehoming/retermination effort must be repaired and restored to working order.

d. A test report must be developed that contains a strip chart for each fiber strand tested, to include the cable ID, strand ID, source location, test set location, dB loss at each wavelength and fiber length, and whether a strand has passed or failed. The test report must also include all raw data files collected from the test equipment used. All strands that passed testing prior to installation must pass testing after installation is complete.

3-9.8 OSP Cable Labeling.

3-9.8.1 Cable Identification/Cable Tags.

Cable Identification/cable tags must be installed at all termination points (terminals) and splices, including house cables. In all OSP supporting structures, all new and existing cables that are part of the project must be tagged and/or retagged between the splice and the wall and on both sides of a splice loop or maintenance loop. When a cable is rehomed to a new location all existing cable tags and terminal labels on the rehomed cable must be re-tagged and re-labeled to reflect the new information. One tag is required for a copper cable pull-through, and two tags are required for an FOC pull-through if there is no service loop. Labels in MHs and HHs must be machine-produced on a durable material suitable for the environment. Handwritten labels are not acceptable.

3-9.8.2 Cable Label Schemes.

The unique identifier for each cable will include an indicator of the originating location of the cable unless directed otherwise by unique project requirements. For a copper cable, it can be as simple as a local policy; e.g., cables 1 through 15 originate from Building xxx; cables 16 through 25 originate from Building yyy. For fiber optic cable, the originating number could be included as part of the identifier. Use the following cable label schemas:

- To identify a copper cable, size + type and cable identification + count are needed. Cable sizes must be identified with an abbreviation. For example, a 1,200 pair cable must be identified as “P12-24PF.” The “24” represents the AWG. PF (plastic insulated cable (PIC) fill) refers to the cable type (fluorinated ethylene propylene). All cables with fewer than 25 pairs must include an “X.” (Refer to the examples.)

Note: Only an existing cable is identified with a “CA” prefix.

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

- To identify a 900-pair, 24 AWG copper cable:
  - P9-24PF = cable size and type
  - 03, 1-900 = cable number and pair count

- To identify two different copper cables under the same sheath:
  - P18-24PF
  - 07, 1-1,500 + T1, 1-300

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

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

- To identify a fiber optic cable, use the cable identification + strand count and then the cable size + type.
  - FOC 01, 1-72 = cable identification and strand count
  - 172 SM = type of cable

- To identify a ribbon type fiber optic cable, use the cable identification + strand count and then the cable size + R (for ribbon) + type.
  - FOC 01R, SM, 1-72 = cable identification and strand count
  - 172 SM = type of cable

3-9.8.3 Identification of Core Network, Distribution Backbone, and Other Unique Cables.

The following requirement does not apply to cables to end user buildings. New cables placed to support core networks, the distribution backbone, and other unique cables must have at a minimum the cable name applied to the cable sheath during the manufacture of the cable. Refer to the site unique requirements for other characters that may need to be applied during the manufacturing process. The number of additional characters that can be applied to the cable sheath varies from 28 to 120 characters by cable manufacturer. Cable tagging is still required for these cables.

Note: Cable naming schemas should not include building numbers, as cable may be rehomed.

3-9.8.4 Existing Cable Labeling.

When an existing cable is rehomed to a location, the new location identifier should apply to all of the rehomed cable, to include laterals. Therefore, all the existing cable tags, the labels on the building terminals, and associated cable records must be changed to reflect the new information. This requirement is not to be construed as a requirement to place labels on cables that do not have existing tags unless the identification of the cable is easy to determine with minimal or no impact on the project's cost or schedule. An example of this is when there is only one cable in the MH, and the identifier and count were verified in the previous MH.

3-9.8.5 Tamper Evident Labeling.

Tamper evident labels must be affixed to all splice cases opened or installed as part of a project and any other major warranted components of the OSP infrastructure. Label components include the following and must be documented:

- type of component
- location of component
- date label was applied to the component
- photograph(s) that show the component and the location where the label was applied

Documentation of components must be provided to the COR at the conclusion of all work.

3-9.9 Demarcation Point Requirements.

The demarcation point is the point where OSP cabling transitions to ISP cabling and where termination and testing can take place.

- A PET is a device that provides electrical protection and a termination point for outside plant cable and indoor house wiring.
- Fiber optic patch panels are devices that provide a termination point for OSP FOC and ISP FOC.

3-9.9.1 Building Entries.

The standard method for entering buildings is through RMC. Refer to Figure A-10 for building entrance details. Use of above-ground entries in lieu of underground entries is permissible with USG approval. The preferred method for creating above ground cable entrance is to use el-shaped rigid conduit bodies (LL, LB, and LR). The riser conduits to must be RMC. Refer to Figure A-21 for above ground building entrances.

Typical foundation types include slab-on-grade, crawl space, full basement, and deep drilling on piles. Refer to Figure A-10 for duct assignment details. Footers encountered may be continuous or non-continuous. The footer portion of the foundation must not be cut. Entrance conduits must pass below footers or through the building foundation wall. RMC must be placed where the entrance conduits pass through foundation walls. Annular spaces between the conduits and floors and walls must be sealed to prevent water intrusion and must be fire stopped in accordance with UFGS 07 84 00, the NEC®, and local codes. The most stringent code applies. Conduits must extend between four to six inches (100 to 150 millimeters) above the finished floor or below the ceiling with bell ends to aid in pulling cables. Entrance conduits must be plugged or sealed to prevent water intrusion. Where conduits entering through the floor cannot be placed within 3 inches (75 millimeters) of a wall, as shown in Figure A-10, the conduits must enter a pull box within the building.

3-9.9.2 Above Ground Entrances.

Entrance conduits must not be mounted on the exteriors of buildings unless previously approved by the USG. Annular spaces between the conduits and floors and walls must be sealed to prevent water intrusion and must be fire stopped in accordance with UFGS 07 84 00, the NEC®, and local codes. The location of existing main telephone terminal rooms on floors above the ground level is insufficient cause to justify mounting entrance conduits on the exteriors of buildings. Where approved by the USG, the number of conduits mounted on the external walls of buildings must be minimized.

3-9.9.3 Pull Boxes and Conduit Bodies.

Pull boxes and conduit bodies must be sized in accordance with the cable manufacturer’s recommended cable bending radius to accommodate the fiber optic and copper cables sized for the building. Conduit bodies are preferred for use where conduits enter the exterior walls. The contractor must obtain approval from the COR to install external pull boxes in lieu of installing conduit bodies. Conduit bodies are more robust and have a smaller footprint than pull boxes. The contractor must coordinate the location and finish of the above ground building entrances with the COR.

3-9.9.4 Transition.

The transition from plastic to RMC for entrance conduits must take place at the bottom of the trench prior to sweeps or bends to the building.

3-9.9.5 Building Telecommunications Grounding.

The contractor must ensure that the various grounding electrode systems, electrical grounding system, lightning protection grounding systems, telecommunications grounding system, and cable grounding system are bonded together. Unclassified TRs must be connected to the building's earth electrode subsystem in accordance with the latest issuance of ANSI/TIA 607. An acceptable grounding system encompasses fault protection grounds, lightning protection grounds, signal grounds, and DC power grounds (when applicable). Refer to UFC 3-575-01 for proper lightning protection and to NFPA 70® for proper fault protection grounding. The contractor must review applicable project drawing(s) to ensure that the lightning and fault protection grounds are addressed by the appropriate disciplines.

3-9.9.6 Building Ground.

The contractor must bond all edge and core network devices to the building earth electrode system (EES) in accordance with the latest issuance of ANSI/TIA 607. The contractor must be conscious of the proposed use of the facility; international, national, or local codes; DoD and Service standards; and/or manufacturers' equipment specifications, and should plan accordingly.

3-9.9.7 Cable Entrance Grounding.

The contractor must ensure that lightning protection complies with UFC 3-575-01 and ensure all grounding electrode systems are bonded together. All metallic shields and strength members for OSP cable entering a building must be bonded to the lightning protection ground system.

3-9.9.8 Copper Cable Entrance.

The designer must use a non-bonded splice case for the transition from OSP-rated cable to interior-rated cable or must indicate that the implementer must not install the splice case carry-through bonding conductor. The OSP copper cable shield, armor, and metallic strength member must be bonded to the lightning protection ground as close to the building point of entrance as possible with a No. 6 AWG bonding conductor in accordance with the latest issuance of ANSI/TIA 607. If the contractor extends the OSP copper cable past 50 feet (15 meters), in accordance with NFPA 70®, the metallic strength member must be bonded to the lightning protection ground as close to the conduit egress point as possible with a No. 6 AWG copper bonding conductor.

3-9.9.9 Surge Protector.

The contractor must terminate all OSP copper cables using surge protectors. Surge protectors are primary protector blocks equipped with 5-pin solid state or gas protector modules. The guidance on surge protection and proper bonding to the grounding system is found in IEEE C62.43. The protector blocks must be bonded to the building ground system with a No. 6 AWG bonding conductor. Terminals, surge protection modules, and hardware must be UL-listed. The PET for European projects must be equipped with protected, LSA+ terminal blocks.

3-9.9.10 FOC Entrance.

The designer must use a non-bonded splice case for the transition from OSP-rated cable to interior-rated cable or must indicate that the implementer must not install the splice case carry-through bonding conductor. The OSP FOC armor and metallic strength member must be bonded to the lightning protection ground as close to the building point of entrance as possible with a No. 6 AWG bonding conductor. If the contractor extends the OSP FOC armor past 50 feet (15 meters), in accordance with NFPA 70®, the metallic strength member must be bonded to the lightning protection ground as close to the conduit egress point as possible with a No. 6 AWG copper bonding conductor.

CHAPTER 4 AIR FORCE SPECIFIC REQUIREMENTS

4-1 REDUCE COSTS, ENHANCE SAFETY.

Follow industry trends of roll pipe and air-assisted cable pathway utilization to reduce the real property cost and complexity of traditionally designed MH and ducting systems from the Bell System era.

Retirement of high pair count, large diameter copper-cabling-based plain old telephone and time domain multiplexing (TDM) equipment has greatly reduced the need for expensive large capacity MHs and ducting. New conduit and cabling system installation technologies have the potential for significant cost avoidance because installations can be designed with longer uninterrupted spans, and do not adhere to the same requirements for maximum number of degrees of direction change before MH installation is needed for traditional "pulled installation" cable. This results in far fewer, if any, MHs within the design, reducing cost and number of additional dangerous confined spaces to an installation's infrastructure baseline.

4-1.1 Copper Cable.

Install new copper cable only when the end equipment cannot be updated to fiber optic transmission.

4-1.2 High-Density Polyethylene Microduct Bundles.

a. Where there is no existing and available MH and ducting, directly bury HDPE-jacketed microduct bundles using methods described in this UFC.

b. HDPE microduct bundles between main communication nodes (MCN) must include no fewer than seven individual micro-ducts.

c. HDPE microduct bundles between EUBs must include no fewer than four individual microducts.

d. HDPE microduct bundles must not exceed 2000 feet (610 meters) in length without MH/HH or above-ground enclosure access to the span.

4-1.3 Conduit Access Points.

To reduce the number of confined spaces on Air Force installations and in areas of rocky terrain, use above-ground enclosures for conduit access points whenever possible.

4-1.4 Cable Sizing.

Adhere to Table 3.8, "Standard Fiber Cable Sizing Between Buildings," with the following modifications:

- Column 3 heading: Originally Installed Fiber Strands Shall Not Exceed
- Column 4 heading: Do Not Exceed Strand Count if Installing New Cable

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CHAPTER 5 ARMY SPECIFIC REQUIREMENTS

5-1 INTRODUCTION.

5-1.1 Purpose.

This chapter provides additional requirements and guidance for Department of Army projects.

5-1.2 Army Technical Authority.

The Army's technical authority for this UFC is an Army employee regularly engaged in the design of information and communication technology. The Army Technical Authority should also have a BICSI RCDD certification. The delegated role of the Authority Having Jurisdiction (AHJ) does not change.

5-2 SPECIFIC REQUIREMENTS.

5-2.1 USG-Designed Projects.

Refer to Chapters 2 and 3.

5-2.2 Classified Infrastructure.

Use the following documents for projects that include SIPRNET requirements:

- *SIPRNET Technical Implementation Criteria*, U.S. Army Information Systems Engineering Command (AKO login required). https://www.us.army.mil/suite/files/5744948

- UFGS 27 05 29.00 10 https://www.wbdg.org/ffc/dod

5-2.3 Telecommunications Spaces.

5-2.3.1 Collocation of Other Telecommunication Systems.

CATV, CCTV, fire alarm and electronic security systems (ESS) may be collocated inside the TR.

5-2.3.2 Multi-Story Buildings.

Refer to Chapter 2.

5-2.3.3 Barracks, Dormitory, and Bachelor Quarter Telecommunications Room Sizing Considerations.

Standard TIA-569 TRs are typically too large for these types of facilities. Provide an 8-foot by 10-foot (2.4-meter by 3.0-meter) main TR on the first floor and provide a minimum of one 6-foot by 8-foot (1.8-meter by 2.4-meter) TR on subsequent floors.

Provision the TRs in these facilities in accordance with TIA-569. Telecommunication enclosures are acceptable in barracks with non-linear designs..

5-2.4 Telecommunications Pathways.

Refer to Chapter 2.

5-2.5 Fiber Optic Backbone Cable.

The Defense Information System Network (DISN) Enterprise Network Installation and Campus Area Network (ICAN) design and implementation standards and specifications dictate use of single mode fiber cables for building backbones on Army projects.

5-2.6 Work Area.

5-2.6.1 Outlet Types and Density for Barracks, Dormitories, and Bachelor Quarters.

Use outlets with a minimum of a “F” type jack and a category CAT6A jack. Locate outlets in the kitchen, living room, family room, and all bedrooms adjacent to a duplex electrical receptacle.

5-2.6.2 General Range Information Infrastructure Design.

With the advent of digital ranges, the preferred infrastructure to ranges is an underground infrastructure, consisting of a two-way conduit system. Direct-buried cable may be used when directed by the USG.

The minimum conduit size for ranges must be no less 1.5-inch (40-millimeter) trade size conduits. The minimum depth for conduit or cable placement is 48 inches (1200 milimeters). Coordinate with the mission owner to determine the required depth.

a. Splices must be placed in underground concrete supporting structures with an HS-20 load rating. Use of buried composite concrete fiberglass is not permitted. Support structures must be large enough to accommodate cable service loops and splice cases.

b. Concrete encasement or galvanized RMC must be used in range projects under road crossings, heavy equipment (tank) crossings, and high-traffic areas. The contractor must plan for a minimum of two, 1.5-inch (40-millimeter) conduits under road crossings. For heavy equipment traffic loads (e.g., tank crossings), the contractor must design and install a pathway based on the maximum expected wheel load. The encasement and/or galvanized RMC must be extended a minimum of 6 feet (1800 millimeters) beyond the road bed for all road crossings.

c. The contractor must also specify a minimum of 12 strands of SM FOC to the individual ranges or range buildings.

5-2.6.4 Inter-Building and Outside Plant Requirements.

Follow Chapter 3 of this UFC.

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CHAPTER 6 NAVY SPECIFIC REQUIREMENTS

6-1 INTRODUCTION.

6-1.1 Purpose.

This chapter provides additional guidance and planning information for Department of the Navy (DoN) projects that will require Navy and Marine Corps Internet (NMCI) network connections. Navy medical facilities must comply with the Defense Medical Facilities Office (DMFO) criteria, including UFC 4-510-01, and are not normally part of NMCI.

Note: For this UFC, the term "NMCI" references the network provided for use by the Navy and Marine Corps; Next Generation Enterprise Network (NGEN) references the contract between the USG and the contractor providing the NMCI network service.

All Naval Facilities Engineering Systems Command (NAVFAC), Facilities Engineering Commands (FEC), Public Works Departments (PWD), Resident Officer in Charge of Construction (ROICC) offices, BCO, and other concerned parties must refer to this UFC when designing, planning, or preparing documentation for new projects that will require operational NMCI support.

6-1.2 Order of Precedence.

If conflicts arise between this UFC and the NGEN contract, the NGEN contract governs.

6-1.3 Coordination.

Although this UFC was written to be as inclusive as possible, IT installations may vary greatly from building to building. It is therefore imperative that the USG facilities team (Naval Enterprise Networks (NEN) Program Office, Commander Navy Installations Command (CNIC), and NAVFAC components), facility design team, and construction contractor coordinate closely at each stage of planning, design, and construction. The telecommunications system DOR must coordinate their efforts for each design with the applicable entities identified in Figure 6-1.

Figure 6-1 Navy Telecommunications Coordination Chart for Typical Design/Bid/Build for Non-National Capital Region Projects

End User – Customer

1. Establishes requirements for voice and data systems in facility.
2. Discusses requirements with DOR and BCO.
3. Provides DOR with quantity and location of outlets.

Base Communications Office (BCO)

1. Discusses telecommunications requirements (voice) with customer and DOR.
2. Designs and procures the voice portion of telecommunications system with assistance from NCTAMS RC. BCO may not procure systems that extend beyond their delegation of authority ($50,000), nor can they procure electronic key systems, central office equipment, PBX systems or trunk lines.
3. Provides DOR with physical space requirements for active voice equipment, point of service connection for voice system, and incoming voice service duct size requirements.

Telecommunications Designer - DOR

1. Discusses telecommunications requirements with customer and BCO, initially at scoping meeting.
2. Obtains type, quantity, and location of work area outlets from customer.
3. Obtains physical space requirements for active equipment from NMCI and Naval Computer and Telecommunications Master Station (NCTAMS).
4. Provides design for physical infrastructure throughout facility to point of service.
5. Sends Appendix A, DD 1391, and cost estimate to NCTAMS via NAVFAC Project Manager (PM).
6. Sends design plans and specs at each design submittal to NCTAMS, BCO and NMCI/NGEN POC via NAVFAC PM.
7. Resolves and incorporates comments appropriately.
8. Sends NMCI requirements to the NMCI Contracting Officer's Technical Representative (COTR) via PM for user.

NCTAMS Regional Coordinator – (RC)

1. Provides design and procurement assistance to BCO. NCTAMS RC is responsible for procuring all voice systems which extend beyond the BCO's delegation of authority ($50,000) as well as all electronic key systems, central office equipment, PBX systems, and trunk lines.
2. Receives Appendix A, DD 1391, and parametric cost estimate from NAVFAC PM for review and comment.
3. Receives final design plans and specs for all projects being advertised for construction, for information only.

6-2 SPECIFIC REQUIREMENTS FOR NAVY INTRANET CONSTRUCTION.

6-2.1 Collocating Various Systems.

Provide adequate space in TRs to facilitate tenant-owned telecommunications systems and other low-voltage systems such as fire alarm, CATV, CCTV, and ESS.

6-2.2 Bachelor Quarters Considerations.

Standard TIA-569 TRs are normally too large for these types of facilities. For multi-story quarters, provide a minimum of one 8 feet (2.4 meters) by 10 feet (3 meters) main TR on the first floor and a minimum of one 6 feet (1.8 meters) by 8 feet (2.4 meters) TR on subsequent floors. Provide additional TRs on the main and subsequent floors as required to meet system limitations.

6-2.3 Fiber Optic Backbone Cabling.

Provide single mode fiber optic cabling (OS1) on all projects for building backbones to future proof the network and standardize the backbone. Additionally, this permits the option of flattening the network via direct connection to switches in TRs other than the main TR. In existing Navy facilities with multimode cables and switches, coordinate with the activity and the NMCI/NGEN contractor to determine whether the switch optics will be changed to use the single mode backbone, or if multimode cable must also be provided in addition to the single mode. If using multimode, OM3 (which permits data rates up to 10 Gigabits) is first choice. OM2 and OM1 should be used only to supplement existing systems.

6-2.4 Navy-Specific Technical Authorities.

For the purposes of implementing fiber to the desktop, the DOR must have justification in writing from the end user certifying that the 1391 supports this requirement, and from the NMCI/NGEN POC certifying that this requirement is included in their planned system.

6-2.5 Barracks, Dormitory, Bachelor Quarters.

Provide a minimum of one standard telecommunications outlet in each bedroom and common area (living room) of the suite. Comply with FC 4-721-10N.

6-2.6 Utility Rooms.

Coordinate with other disciplines and the Activity to determine if a voice or data outlet is needed in mechanical or electrical utility spaces (for smart metering or automated building control systems).

6-3 OUTSIDE CABLE PLANT.

See Chapter 3.

6-3.1 Pathways.

Coordinate with the NMCI contractor to determine if the NMCI pathways can be routed in the same duct bank with other telecommunication conduits. If so, conduits beyond the 5-foot (1.5-meter) line and manholes are MILCON funded to the closest manhole where service exists. The location of underground structures and the necessary interconnecting ducts must be explicitly described and identified in the contract documents.

For new buildings, provide a minimum of one, 4-inch (103 millimeter) conduit for NMCI service. Provide a minimum of two conduits for multi-story buildings. Use three innerducts (two, 1.5-inch (41-millimeter) and one, 1-inch (27-millimeter)) or three fabric mesh innerducts in each conduit. Install a pull wire inside each of the innerducts. This is in addition to the conduits required for other telecommunications services (telephone, cable television, fire alarm and intrusion detection).

6-3.2 Detection.

Provide electronic detection for each pathway in accordance with the following:

- Use detectable warning tape or tracer wire above the duct back for new installations.
- Use tracer wire when pulling new cable in existing duct systems.
- Terminate all tracer wire in test stations for utility locating personnel with a cover/lid marked “Test Station.”

6-3.3 Cabling.

Standard NMCI practice employs SM FOC with a minimum core size of 8 microns as the transport medium between building EFs.

- Install fiber underground in conduit.
- A minimum of 12 strands of SM fiber is required. Coordinate with the NMCI contractor for additional requirements. Provide fiber with facility contract.
- If classified seats are supported and unencrypted classified communication occurs over the outside plant cabling, conduits are required and normally must be encased in concrete. Comply with applicable PDS requirements, including IA PUB 5239-22.

CHAPTER 7 MARINE CORPS SPECIFIC REQUIREMENTS

7-1 INTRODUCTION.

7-1.1 Purpose.

This chapter will be used by the Marine Corps to provide additional guidance and planning information for USMC projects that will require telecommunications or IT network connections.

Marine Corps projects must use an optical solution as the first course of action when planning and designing new projects. Exceptions to this can be granted only by the Marine Corps installation's advocate or where life safety is concerned due to local building codes. Refer to Chapter 2 of this UFC for non-optical solutions.

Naval Facilities Engineering Systems Command (NAVFAC), Facilities Engineering Commands (FEC), Public Works Departments (PWD), Resident Officer in Charge of Construction (ROICC) offices, installations' G/S-6, and other concerned parties in the process must refer to this UFC when designing, planning, or preparing documentation for new projects.

7-1.2 Marine Corps-Technical Authority.

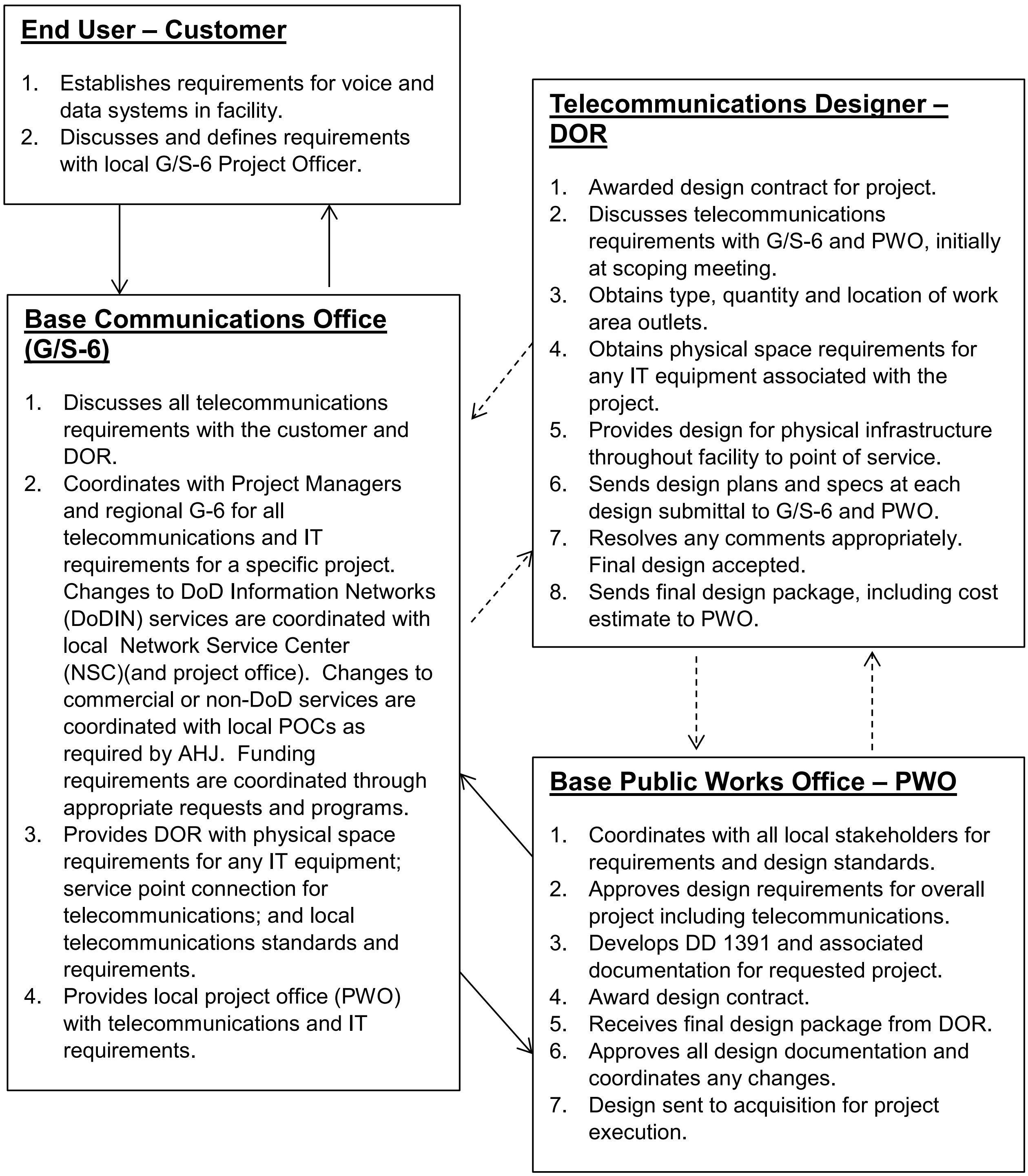
Telecommunications infrastructure must meet the needs of the activity and supporting facilities in accordance with this UFC. Architect/Engineer (A/E) contractor-generated final drawings and specifications for Design-Bid-Build and Design-Build projects must be stamped by a BICSI RCDD. Design and construction may be concurrent efforts in Design-Build projects, and multiple phases may be approved. Therefore, each phase and/or project must be stamped.

Modernization of telecommunications systems within existing facilities solely for the purpose of meeting design criteria in this UFC is not required.

7-1.3 Coordination.

Although this UFC was written to be as inclusive as possible, cable plant electronics installations may vary greatly from building to building. It is therefore imperative that the USG facilities team as stated above, facility designer, and construction contractor coordinate closely at each stage of planning, design and construction. The DOR must coordinate their efforts for each design with the applicable entities identified in Figure 7-1.

Figure 7-1 Marine Corps Telecommunications Coordination Chart for Typical Design-Build and Design-Bid-Build Projects



Note: Solid lines represent customer coordination requirements within installation staff and their tenants. Dashed lines represent contractor-to-installation communication.

7-2 SPECIFIC REQUIREMENTS FOR MARINE CORPS PROJECTS.

7-2.1 USG-Designed Projects.

USG-designed (in-house) projects require the approval of the Service-appointed telecommunications agent, prior to bid, in accordance with regulations, policies, memorandums, and guidance.

7-2.2 Classified Infrastructure.

Classified work areas, rooms and facilities must comply with MCO 5530.14A.

7-2.3 Collocation of Other Telecommunication Systems.

CATV, CCTV, control systems, fire alarm and electronic security systems (ESS) may be collocated inside the TR. Tenant owned systems that are not considered part of the facility are not accorded space within a TR. Planning for an equipment room will be considered as required if there are no other hosting capabilities available. Final decision authority is the site owner.

7-2.4 Telecommunications Rooms.

Follow the general requirements of Chapter 2 with the following additional requirements. Minimum dimensions are 10 feet, 8 inches (3.25 meters) by 12 feet (3.6 meters), meeting all TIA-569 standards with the following exceptions.

- Base sizing of room on the additional systems requirements of the service space such as Building Management System (BMS), Automated Control Management System (ACMS), Intrusion Detection System (IDS), fire-alarm panels, and A/V equipment.
- Provide a minimum of two standard 19-inch (0.5-meter) cabinets per TR. Equipment racks will be used by exception due to physical security requirements and other specific facility requirements.
- In facilities or structures that require only the minimum infrastructure to the EF, one cabinet may be used, and the room resized appropriately. FRCS substations and remote locations may be served by a splitter or other passive connection in a pedestal.
- Mount all cabinets to the permanent floor, centered in the TR to meet Americans with Disabilities Act (ADA) access requirements.
- Colocation support agreements will be established at local level being first Flag Officer (FO)/General Officer (GO).

Treat floors, walls, and ceilings to eliminate dust by providing eggshell or semi-gloss paint finish, light in color, to enhance room lighting. Provide one wall outlet installed at or near the entry door for emergency or primary voice communications.

7-2.5 Cabinet Layout.

Existing TR cabinet layout will include ONTs and optical splitters. Future layouts will have splitter/patch panel in cabinets and ONT at work stations. Locate OLTs at the area distribution node.

7-2.6 Facility Optical Network Terminal Placement.

Do not place rack-mounted ONTs with more than 120 Gigabit Ethernet (GbE) interfaces per PON port off of the OLT. Current ONTs configured with 24-ports are grouped in multiples of five onto a 1:8 or 2:8 (for pathway redundancy) passive optical splitter.

7-2.7 Optical Splitters.

Locate splitters at a central aggregation point or EF when feeding a single ONT at a remote location, EUB, or hybrid A/V rack area. This is the demarcation point of an EUB. Place the optical splitter at the ADN if the facility will house four to five ONTs and will require only a single (or two for redundancy) strand(s) of OSP fiber to the OLT. The minimum strand count for OSP run to remote location is 24 strands. However, if this EUB requires dual homing or special redundancy, locate a secondary 2:1 splitter to connect the ONT and allow for two OLTs to be interfaced into the EUB 2:1 splitter.

It is important to ensure that the optical loss budget is taken into account. As the common point of load (PoL) budget is from -8 to -28dB, there may be a requirement to attenuate the optical signal via a splitter or attenuator to allow for proper ONT operation.

7-2.8 Patch Panels and Patch Cords.

Provide patch panels to support locking or keyed patch cords for improved physical security and the ability to meet fixed emergency communication location requirements. Code or key patch cords in accordance with the type of service they are providing – primary voice, data, video, or Supervisory Control and Data Acquisition (SCADA). Provide a reference color code and naming convention for baseline consistency.

Provide bend-insensitive, pre-terminated patch cords capable of being locked into place to avoid accidental disruption of services or tampering. For OLT to fiber optic patch panel (FOPP) connections, provide SC-UPC to SC-APC patch cords. Provide all other patch cords to match the patch panel they are connecting. LC-APC connectors and patch panel adapter bulkheads are acceptable for increased density; however, they are not permissible at the information outlet faceplate.

7-2.9 Telecommunications Pathways Interior Conduit.

Provide wall-mounted work area outlets with rigid metal conduit stubbed up from the outlet to the horizontal cable distribution system. Use cable trays or non-continuous supports (J-hooks) to support the cable from the TR to the top of the wall containing the work area outlet, then route the cable in the wall cavity to a low-voltage mounting bracket.

7-2.10 Work Area Outlets.

Connect work area outlet face plates to a double-gang, 4-inch by 4 inch (100 millimeter by 100 millimeter) outlet box, at least 3.5 inches (90 millimeters) deep to accommodate fiber inserts, slack management, and potential in-wall signal converters.

7-2.10.1 Type 1 Outlet.

Terminate Type I horizontal fibers in a traditional face plate. Because ONTs typically allow multiple Ethernet interfaces, a single fiber interface per workstation/classification is typically all that is required. This consists of a traditional wall plate equipped with two single-port SC-APC connectors. This scenario provides flexibility in that any ONT type can be used in the design, along with other traditional duplex send and receive fiber pair technologies that may be required under special circumstances.

When using fiber outlets for desktop or surface mounted ONTs, the outlet connectors for the horizontal fiber drop must be an individual snap-in style and fit securely into the face plate housing. The connector must be compatible with single-mode SC-APC fiber. SC-APC is recommended throughout the installation to ensure compatibility with RF video service and future 10G-PON applications employing the 1577 nanometer wavelengths. Angled connectors or inserts with hinged dust covers are recommended to minimize fiber end face contamination.

7-2.10.1.1 Optical Network Terminal Copper Ethernet Interfaces.

For ONTs equipped with Ethernet interfaces, provide a minimum of one (1) 10/100/1000 RJ-45 interface conforming to IEEE 802.3 standards. A quantity of two or four 1000 Base-T interfaces are recommended to comply with current industry best practices. 10/100 Base-T interfaces and those not supporting PoE or PoE+ are not permissible except in scenarios where RF video or plain ordinary telephone services (POTS) are being provided.

7-2.10.1.2 Optical Network Terminal Copper Analog Interfaces.

ONTs equipped with analog POTS provide various quantities (2, 4, or 24 depending on the model) of RJ-11 or RJ-21 telephone jacks for connection of analog devices (telephones, faxes, modems). These interfaces may provide 600 or 900 ohm terminations and adhere to typical analog voice wire length specifications.

7-2.10.1.3 Optical Network Terminal Coaxial Outlet/Connector.

ONTs equipped with RF video interfaces can provide broadcast television service or any RF frequency up to 1 GHz. The coaxial outlet/connector integrated within the ONT is a standard, male 75-ohm “F” type connector. The designer must coordinate with the cable service provider where franchise agreements are in place and additional head-end components such as an RF combiner, laser modulator, and erbium-doped fiber amplifier (EDFA) will be required for PoL distribution of RF services.

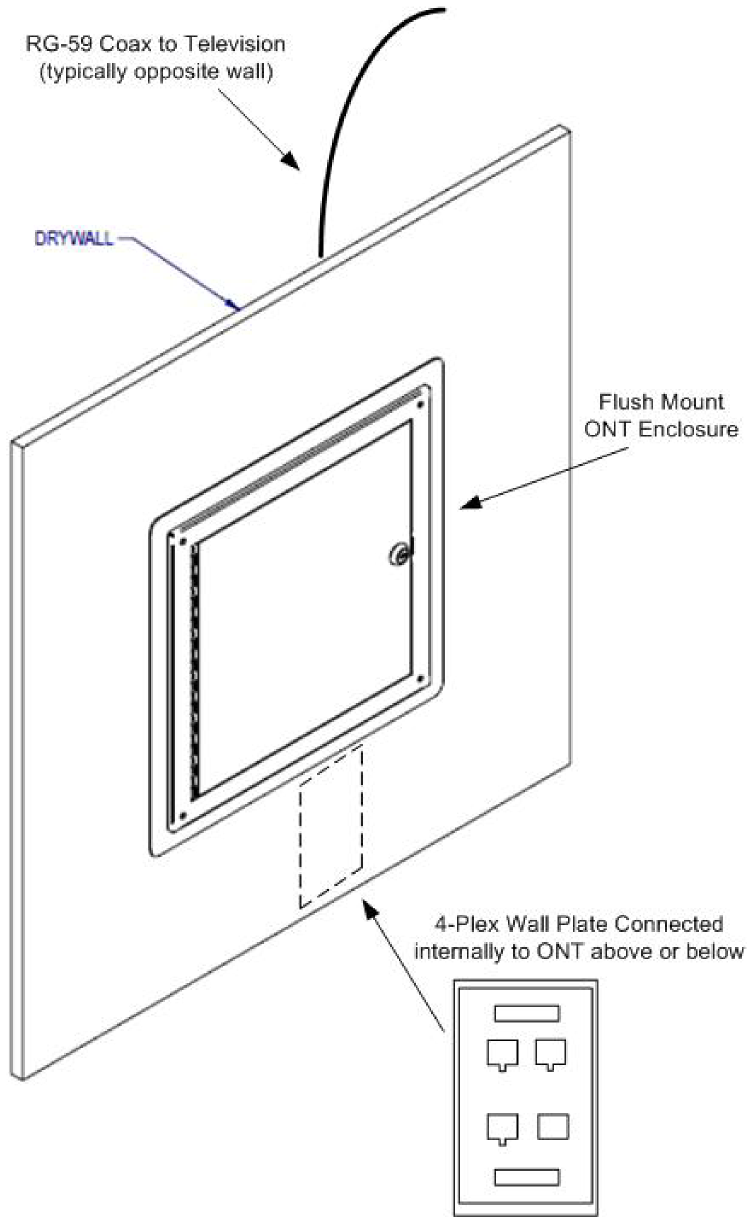
7-2.10.1.4 Optical Network Terminal Density (Port Sharing).

Consider end user requirements for the number of information outlets at a workstation when designing a POL system layout. While some IP endpoints (including printer locations, IP surveillance, access control entry points, and building automation systems) may require multiple ports for connectivity to various Ethernet devices or multiple networks, there are many instances where a workstation or IP endpoint need only connect to perhaps one or two network interfaces. In this scenario, it is acceptable to allow for port sharing between ONTs to increase the operational and financial savings associated with the POL deployment. In the port sharing deployment, adjacent cubicles or modular workstations can share the ports of a single ONT by distributing copper Ethernet patch cords between the cubicles. The quantity depends upon the number of required interfaces for each workstation and/or the forecasted growth of the end user's network requirements. In many cases, an IP telephone can be installed in tandem with a user's PC or workstation eliminating the need for a duplex Ethernet jack per user. This allows for as many as four users to share a single, four-port ONT, for example. Another scenario provides two jacks per workstation so that the ONTs are shared at a 2:1 ratio. Regardless of port sharing, the designer must provide a single work area outlet (WAO) at each workstation for future growth and flexibility.

7-2.10.2 Type 2 Outlet.

The Type 2 outlet mirrors the approach of a Type 1 deployment with the exception of the termination of the ONT at the end user workstation or IP endpoint. The Type II deployment will provide protection of the ONT from tampering, disruption of service, and environmental anomalies such as liquid spills, dust, or even vandalism. Enclosures are also recommended in medical facilities, conference rooms, or common areas to conceal cabling and ensure continuity of operation. All connectivity to the ONT (power, fiber port, Ethernet, analog voice, and RF video) may be contained within the enclosure and end user information outlets can either extend externally from the enclosure to a face plate apparatus, or exit the enclosure via pass-through devices. The location of the information outlets is dependent upon end user requirements and whether the enclosure is surface-mounted or flush-mounted. See Figure 7-2.

Figure 7-2 Flush-mounted ONT Enclosure



7-2.10.3 Type 3 Outlet.

Type 3 deployments allow for a hybrid approach to passive optical LATB infrastructures. Type 3 deployments are appropriate where TRs exist and are not planned to be re-purposed after installation of the PON. Type 3 deployments are also appropriate where a viable copper cabling infrastructure exists and is not in need of a technology refresh. Type 3 systems use high-density ONTs (typically 24 Ethernet ports) which are then patched to the horizontal copper cabling drops as does a legacy system using workgroup switches. Type 3 deployments allow for a migration strategy to fiber-to-the-desktop architectures and can readily accommodate technology refreshes where the legacy work group switches must be replaced.

The workstation outlet used in a Type 3 architecture consists of standard category rated copper cabling per Chapter 2 of this UFC. The WAOs in this architecture are commonly in place prior to the upgrade or replacement of the active electronics to POL. A new copper plant is recommended, but not required, to provide flexibility in the types of networks patched into the POL or for special sources.

Note: Refer to Chapter 2 of this UFC for additional outlet types and design standards for copper or optical-based interior telecommunication wiring.

7-2.11 Installations Communications Grid (ICG) or Backbone Cabling.

Provide a minimum telecommunications service to all new facilities consisting of one 25pr copper cable and one 24 strand, single mode (OS1) fiber optic cable through a minimum of two, 4-inch (100-millimeter) ducts. Provide additional cable count in accordance with maximum population and workspace requirements per facility type.

APPENDIX A STANDARD DRAWINGS

Figure A-1 Drawing Symbols and Legend

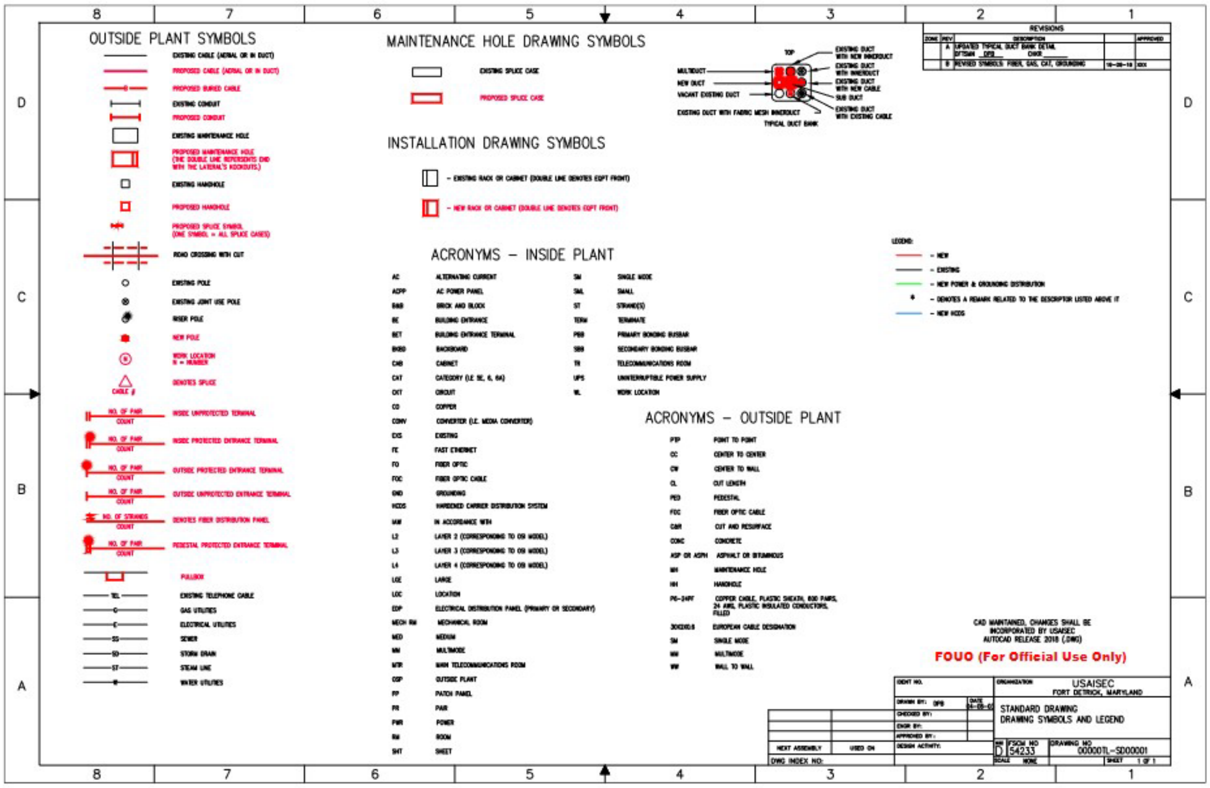


Figure A-2 Conduit Placement and Cut and Resurface

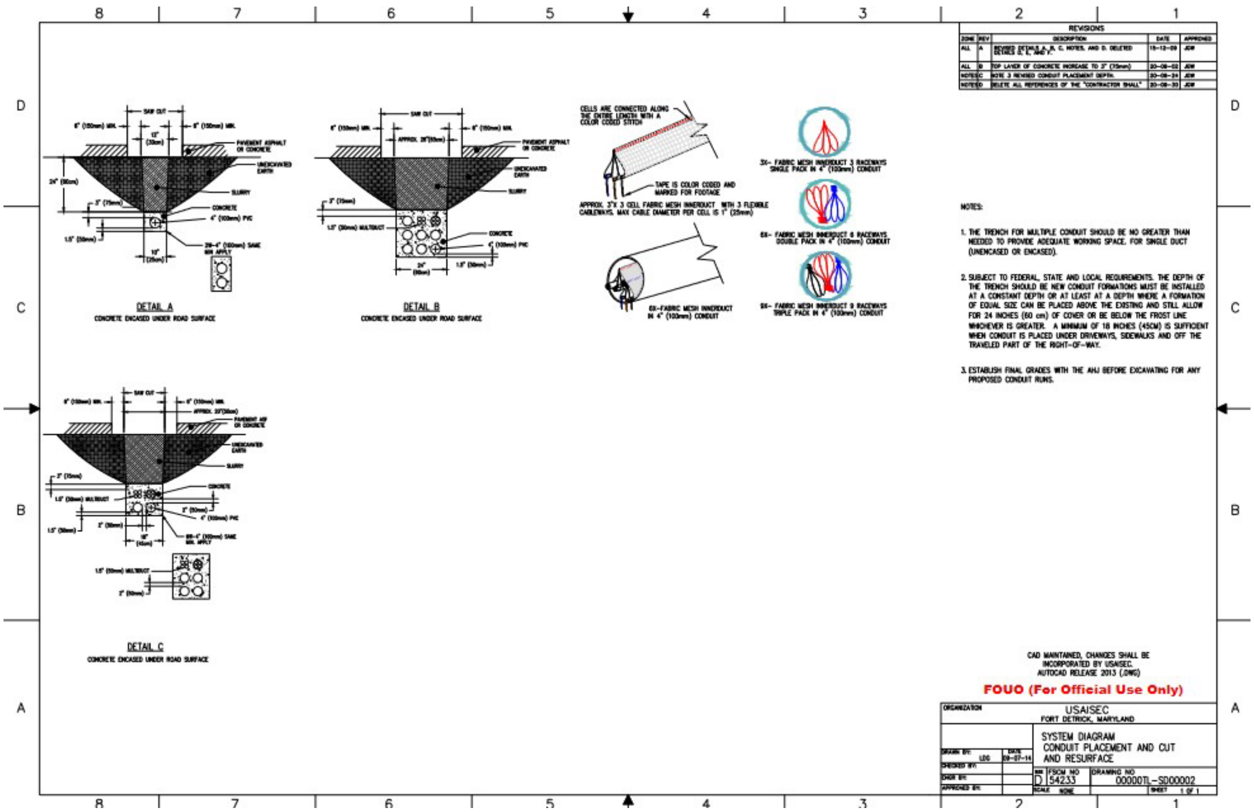


Figure A-3 Conduit in Casing Placement

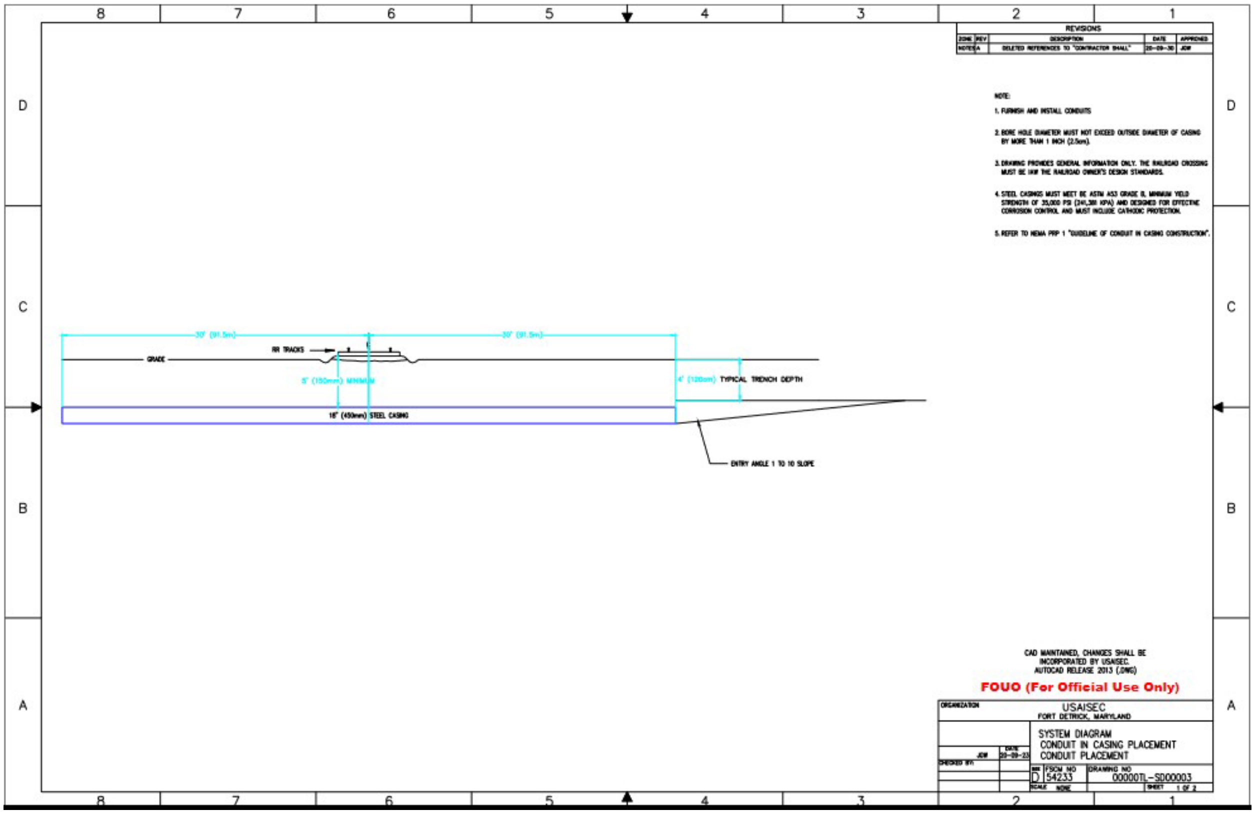


Figure A-4 Double Stepped Tee-Cut and Resurface Details

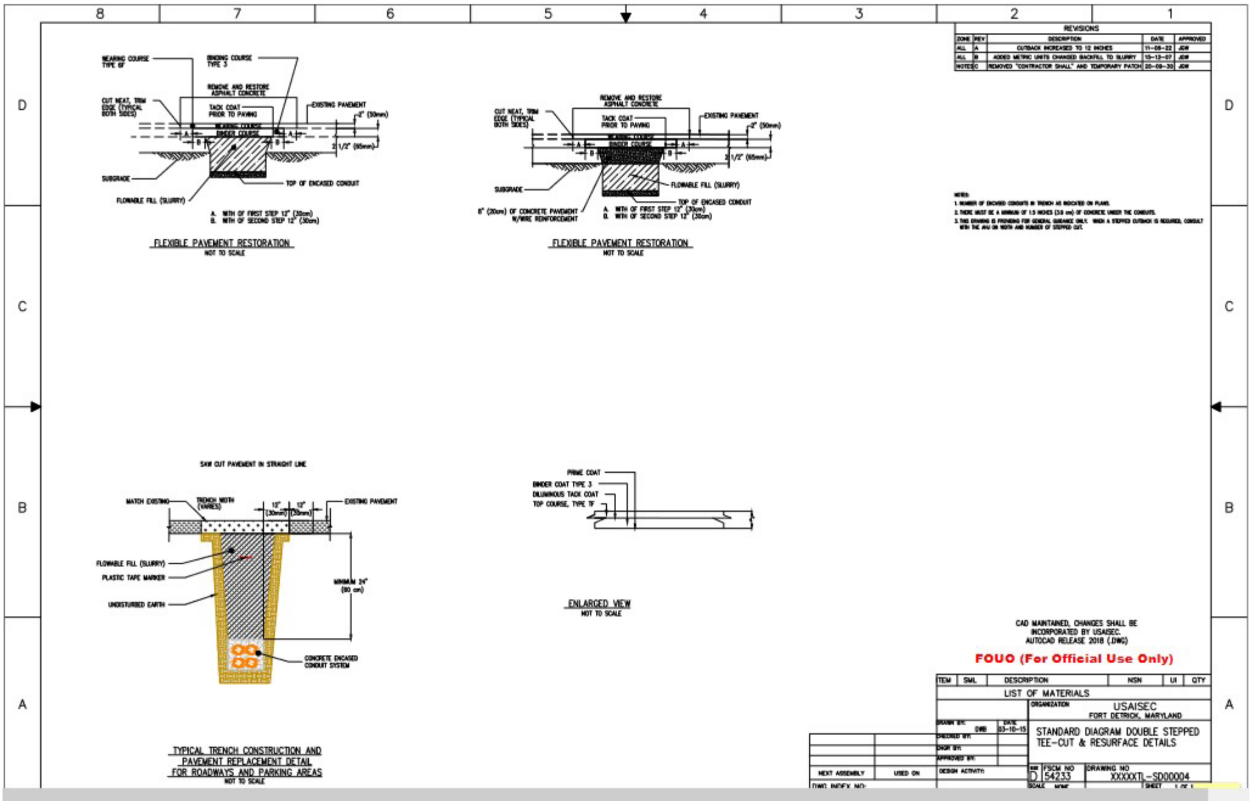


Figure A-5 Large Maintenance Hole Detail - Typical

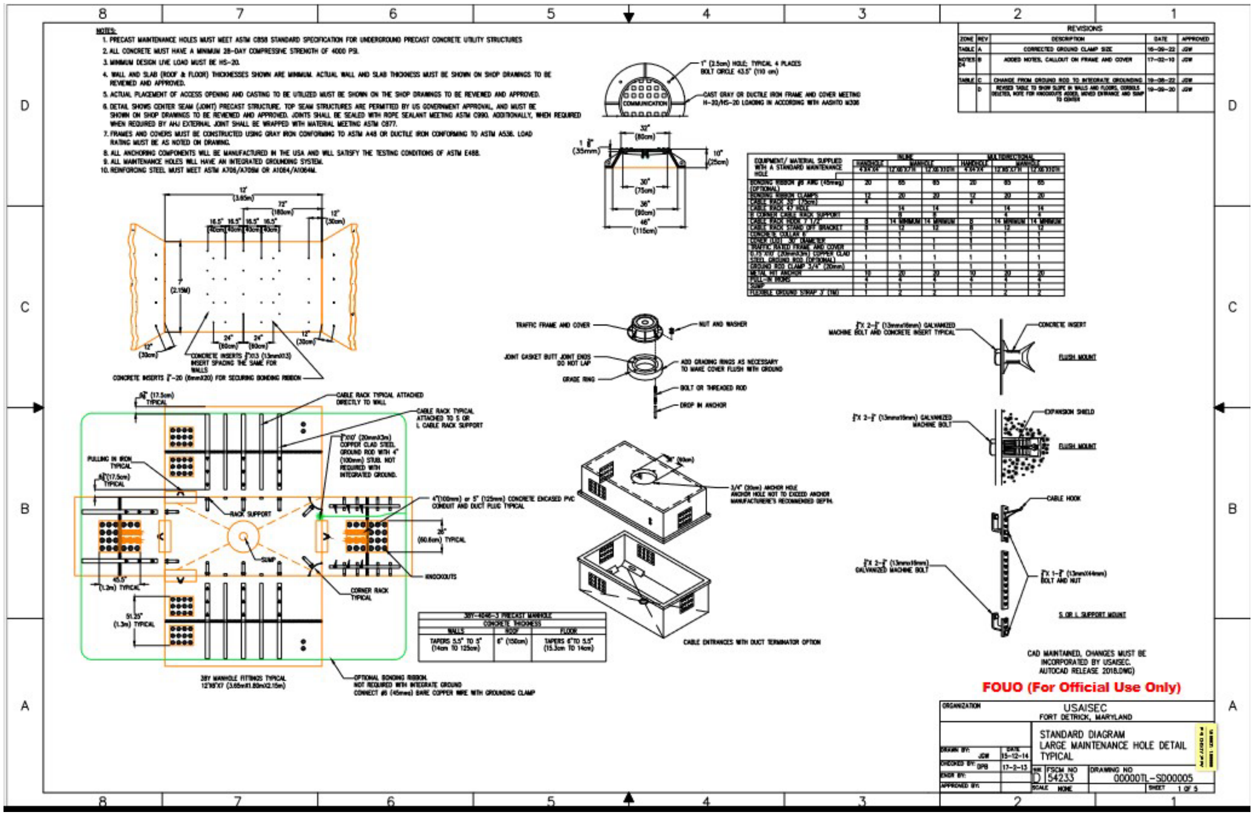


Figure A-6 Splay Maintenance Hole Detail - Typical

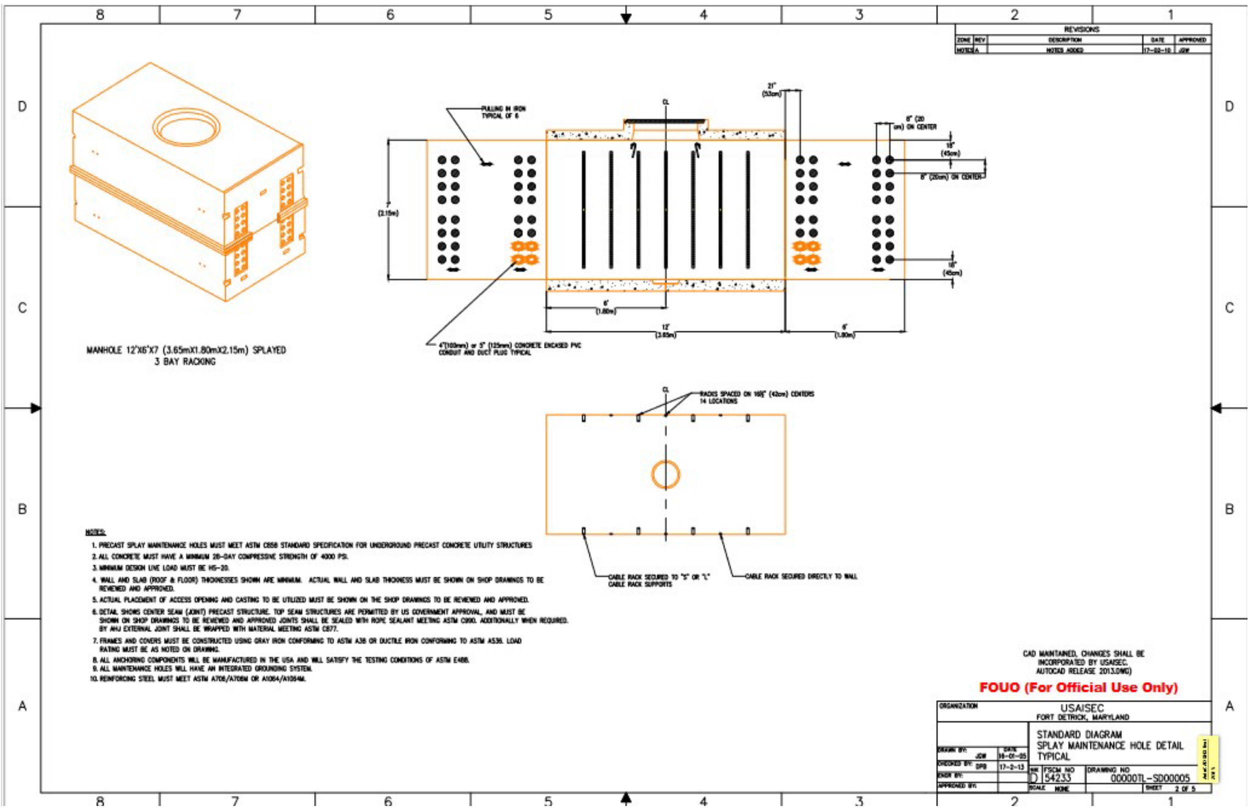


Figure A-7 E80 Rated Maintenance Hole Detail – Large Typical

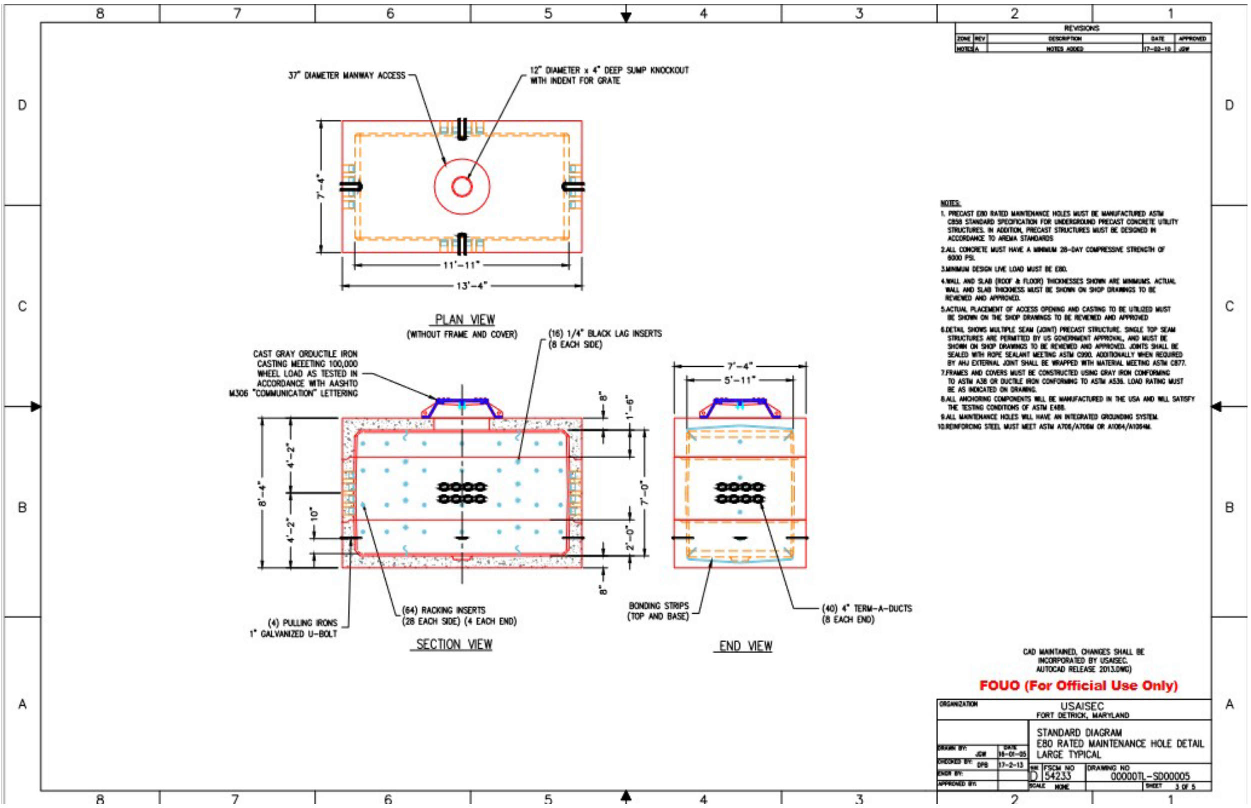


Figure A-8 E80 Rated Maintenance Hole Detail – Medium Typical

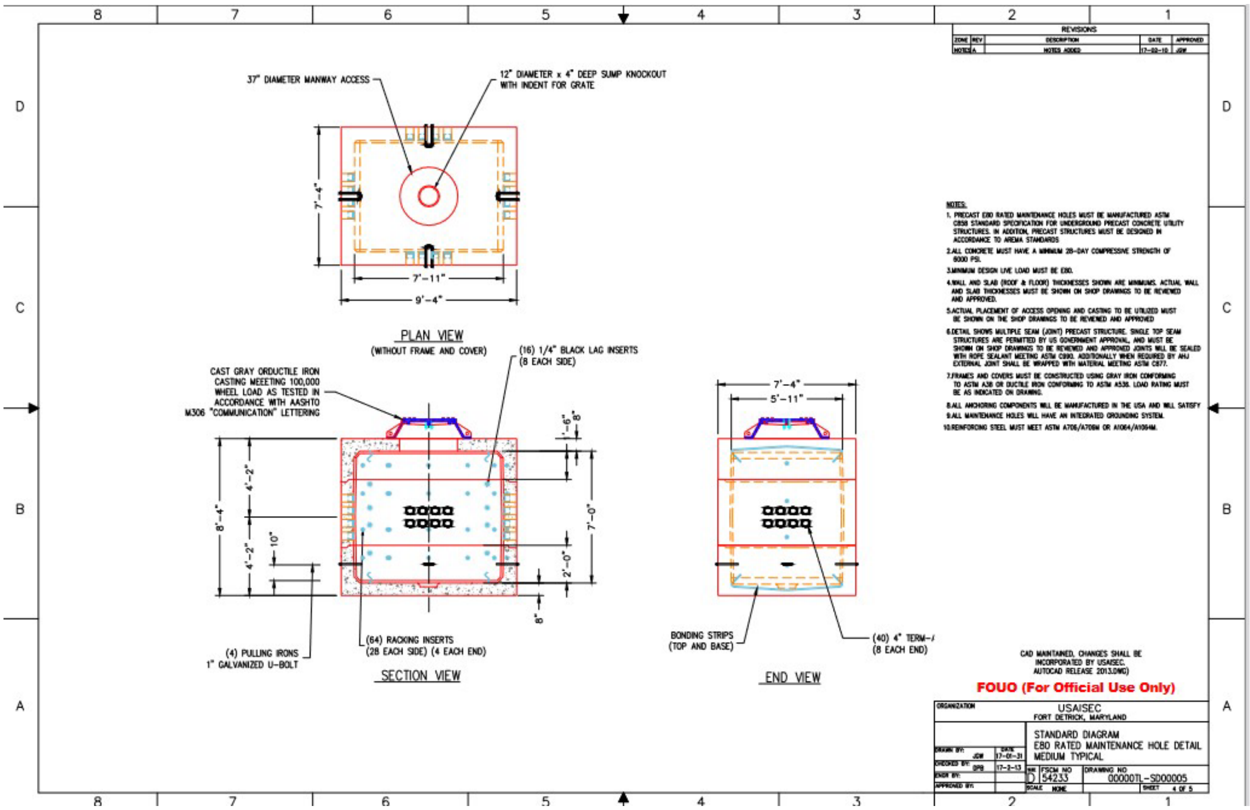


Figure A-9 Type V-1 Maintenance Hole

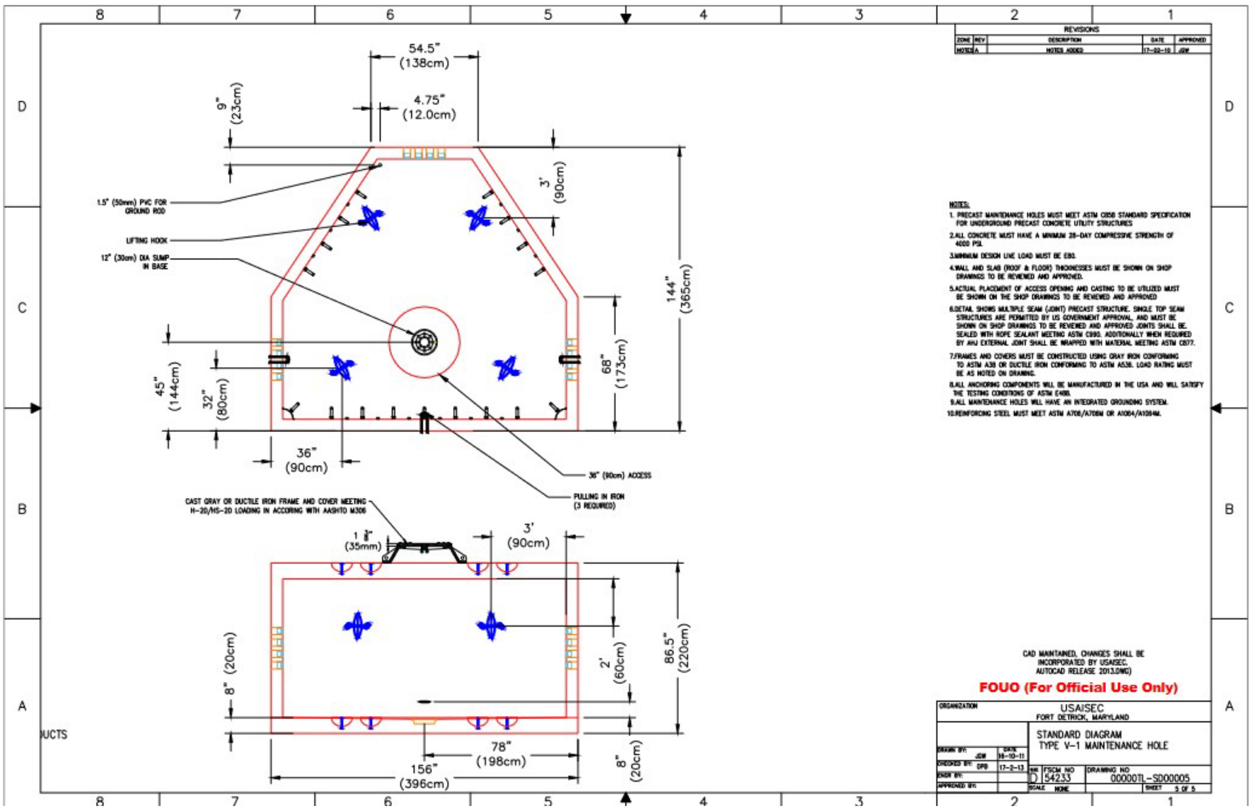


Figure A-10 Pedestals and Building Entrance Details (Sheet 1 of 3)

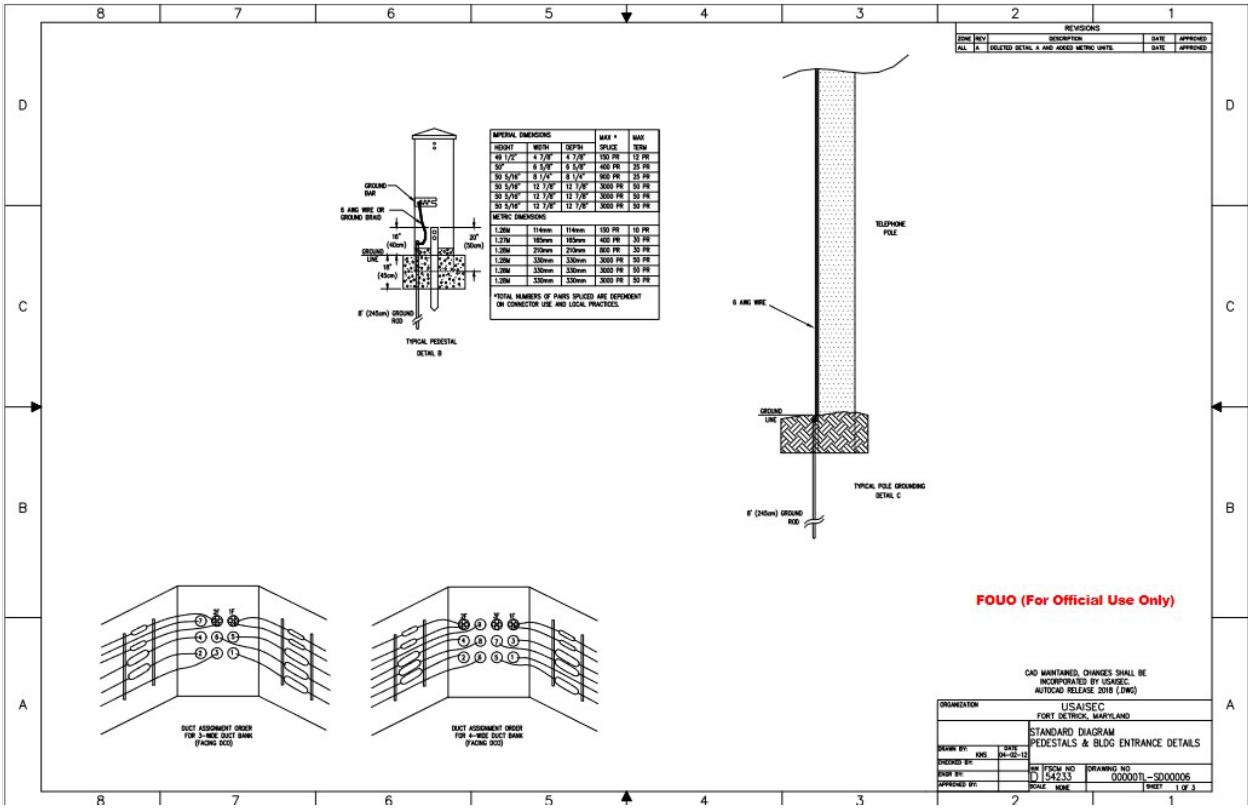


Figure A-10 Pedestals and Building Entrance Details (Sheet 2 of 3)

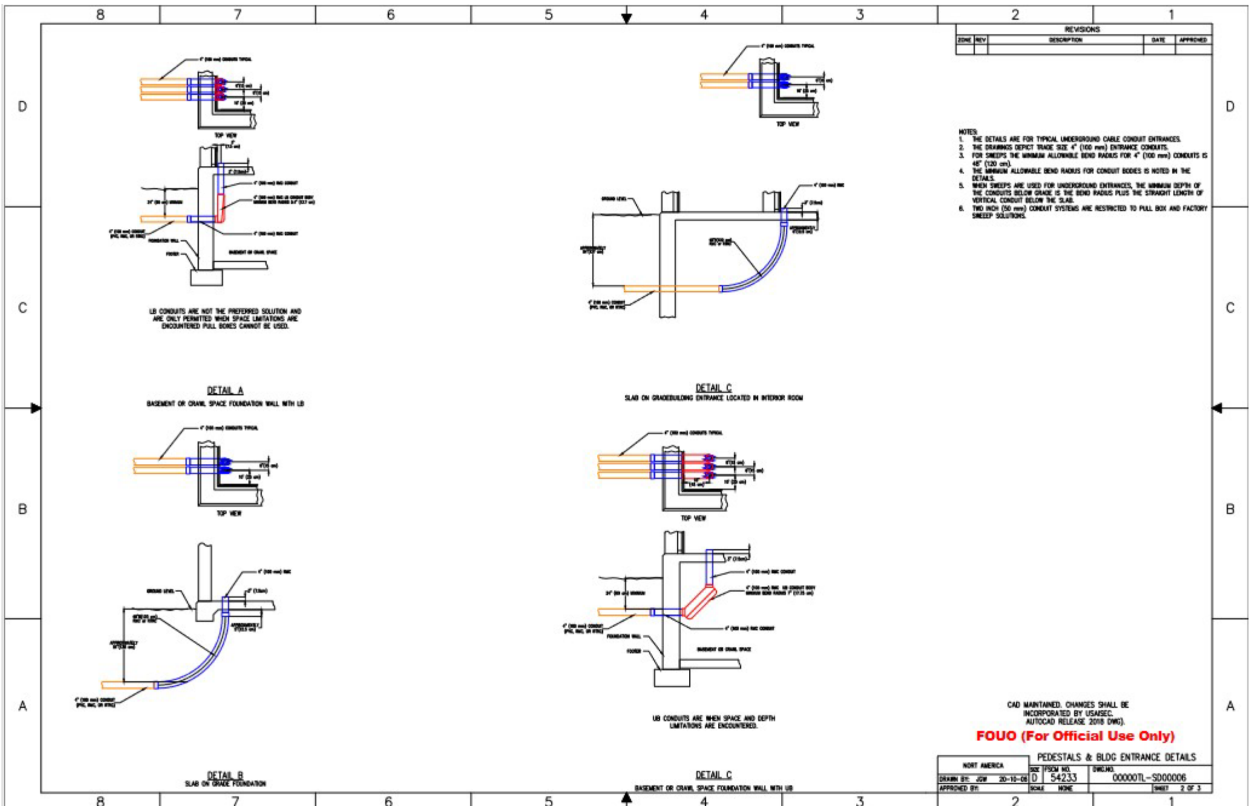


Figure A-10 Pedestals and Building Entrance Details (Sheet 3 of 3)

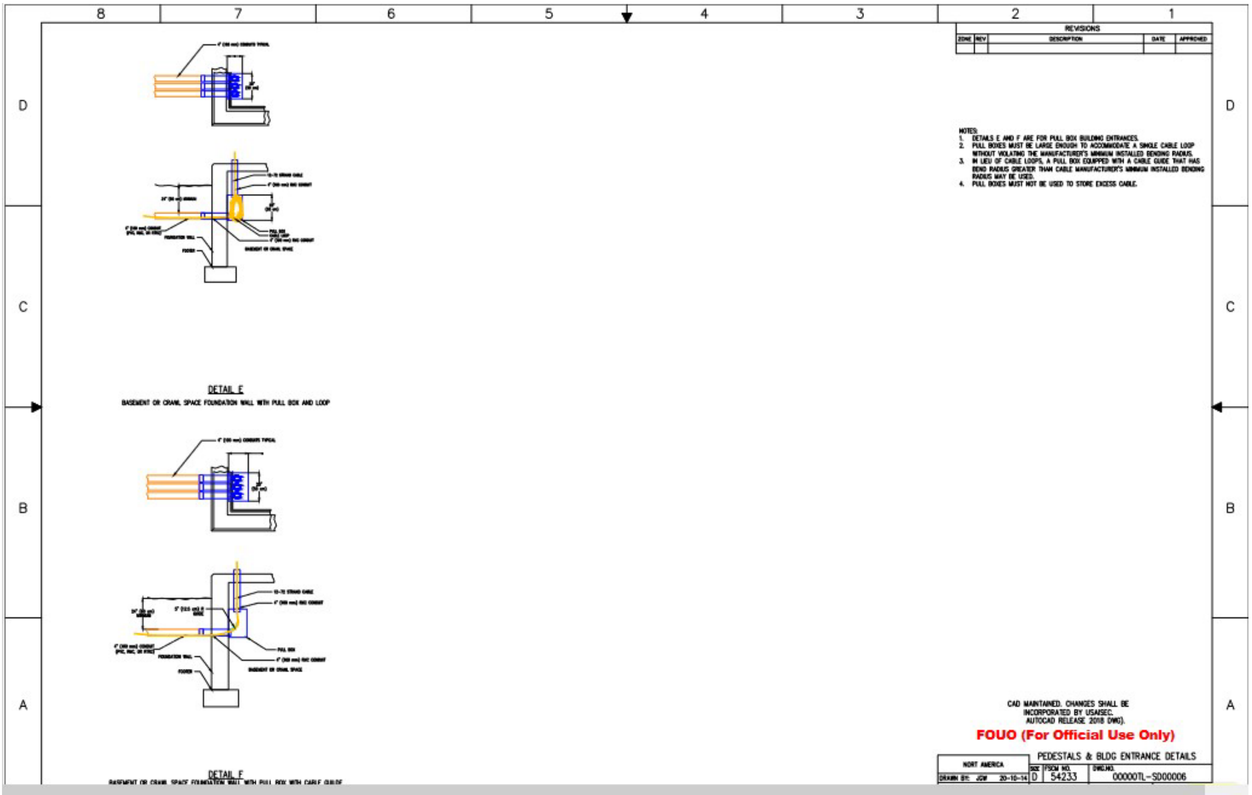


Figure A-11 Main Frame Drawing MDF and Cable Vault Schematic

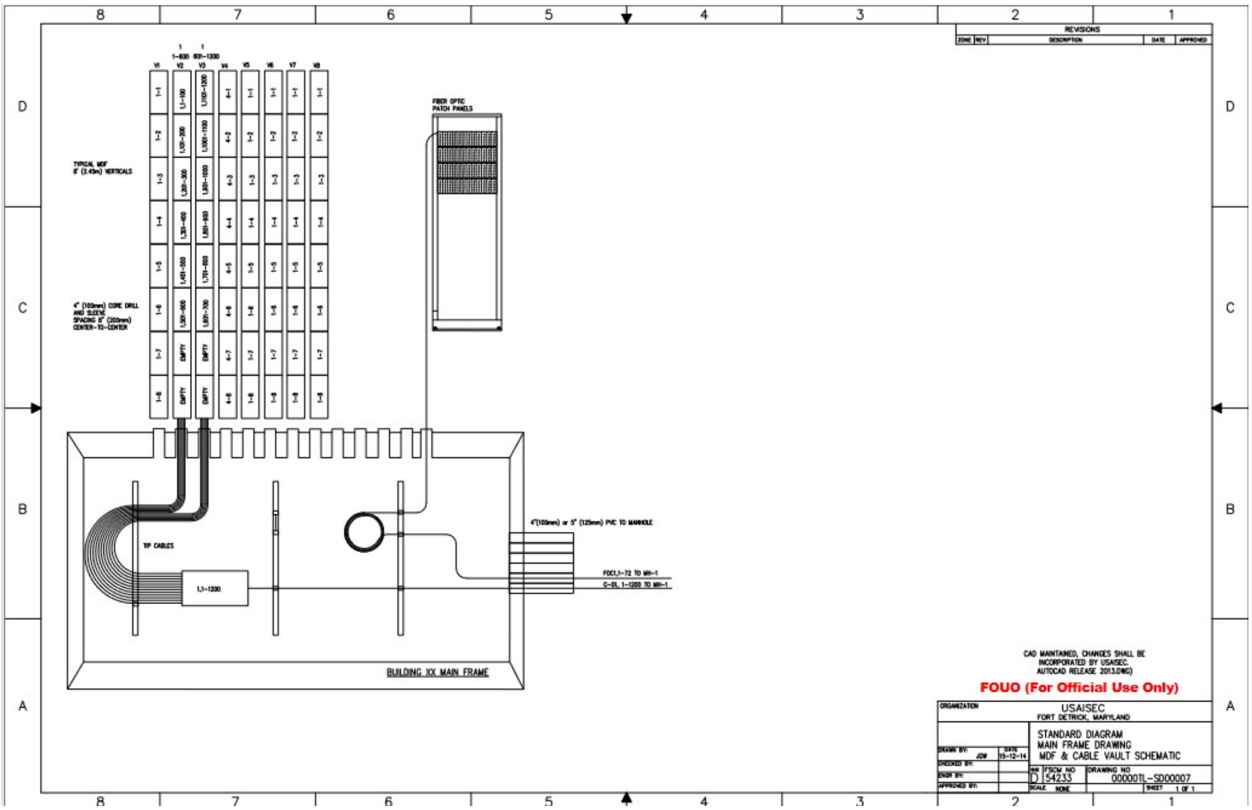


Figure A-12 Pipe Bollard Construction Detail

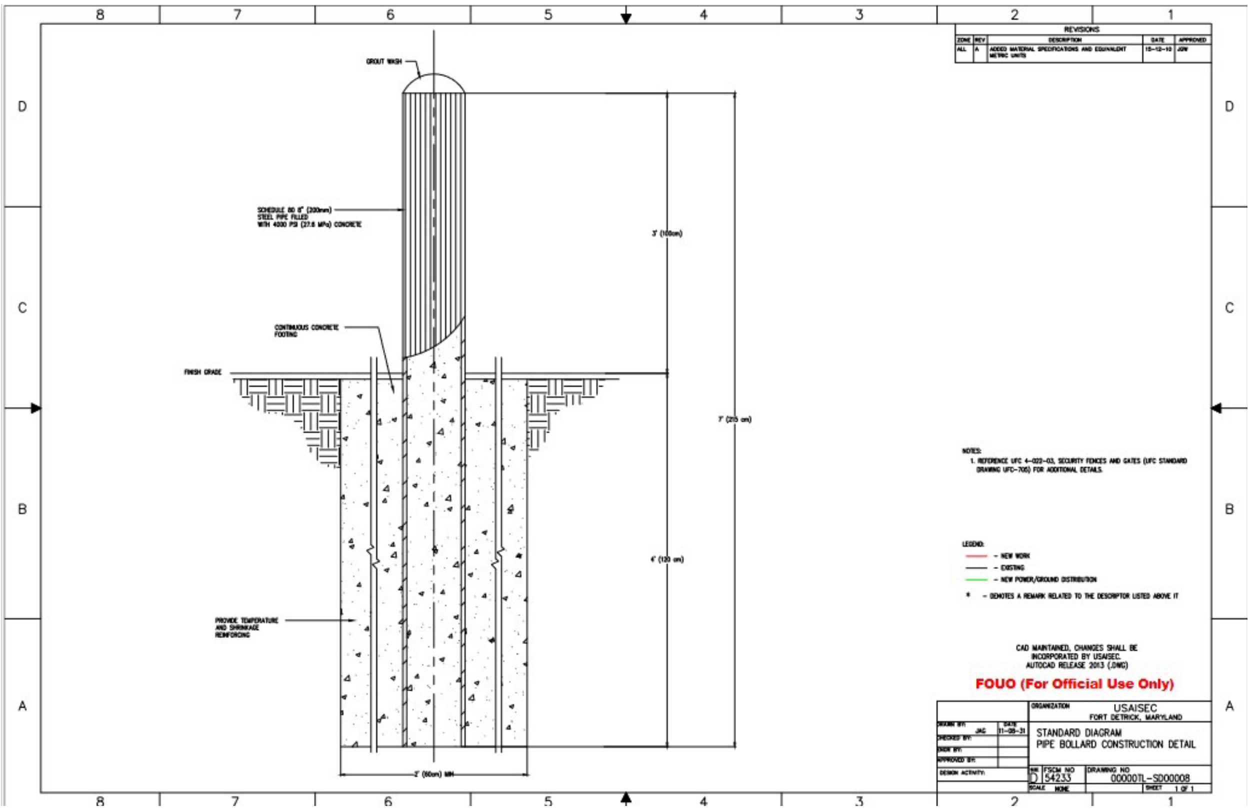
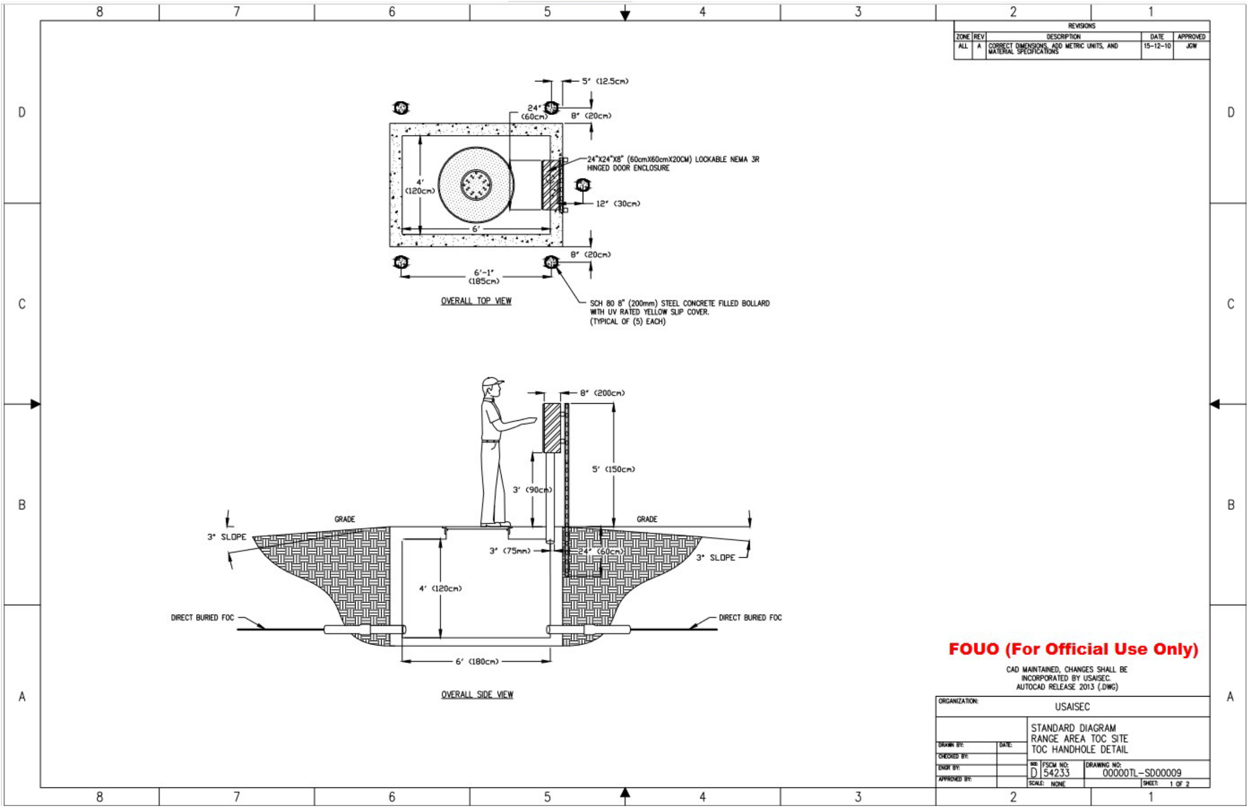


Figure A-13 Range Area TOC Site – TOC Handhole Detail



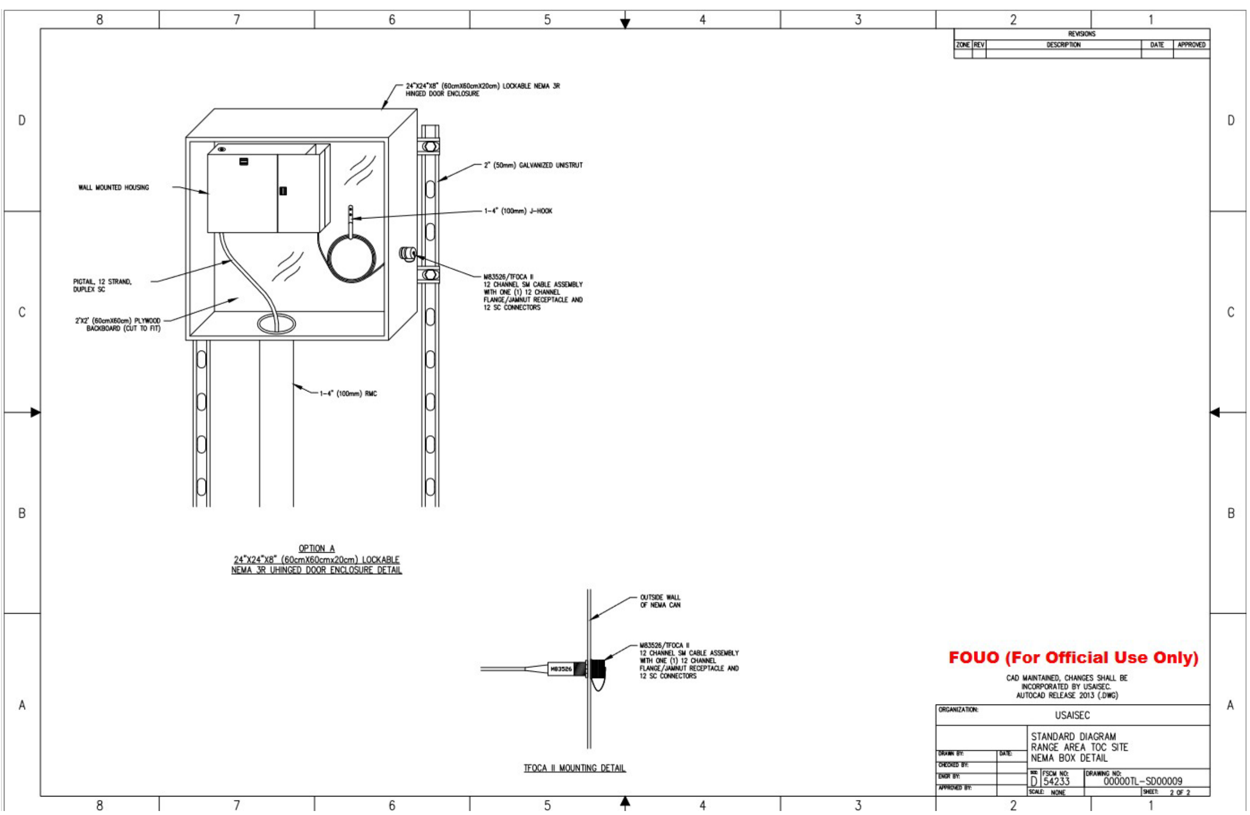


Figure A-14 Range Area TOC Site NEMA Box Detail

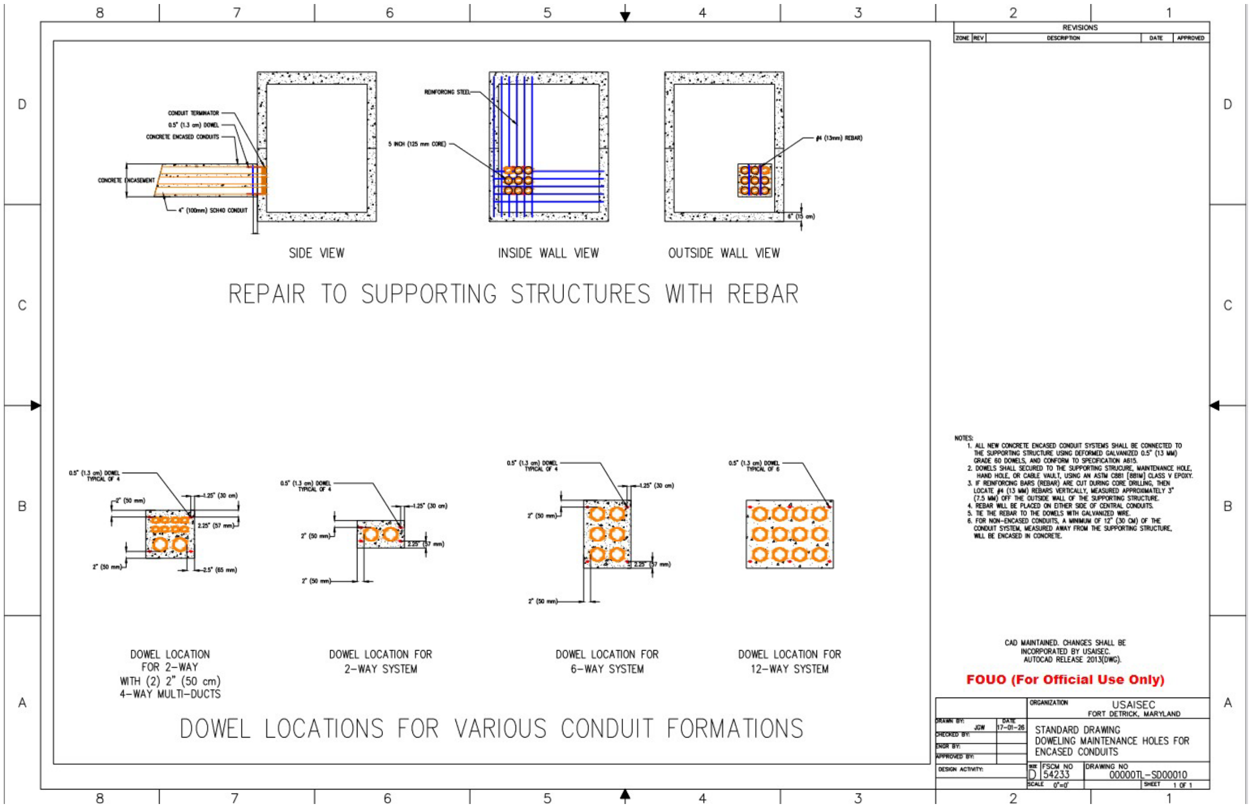


Figure A-15 Doweling Maintenance Holes for Encased Conduits

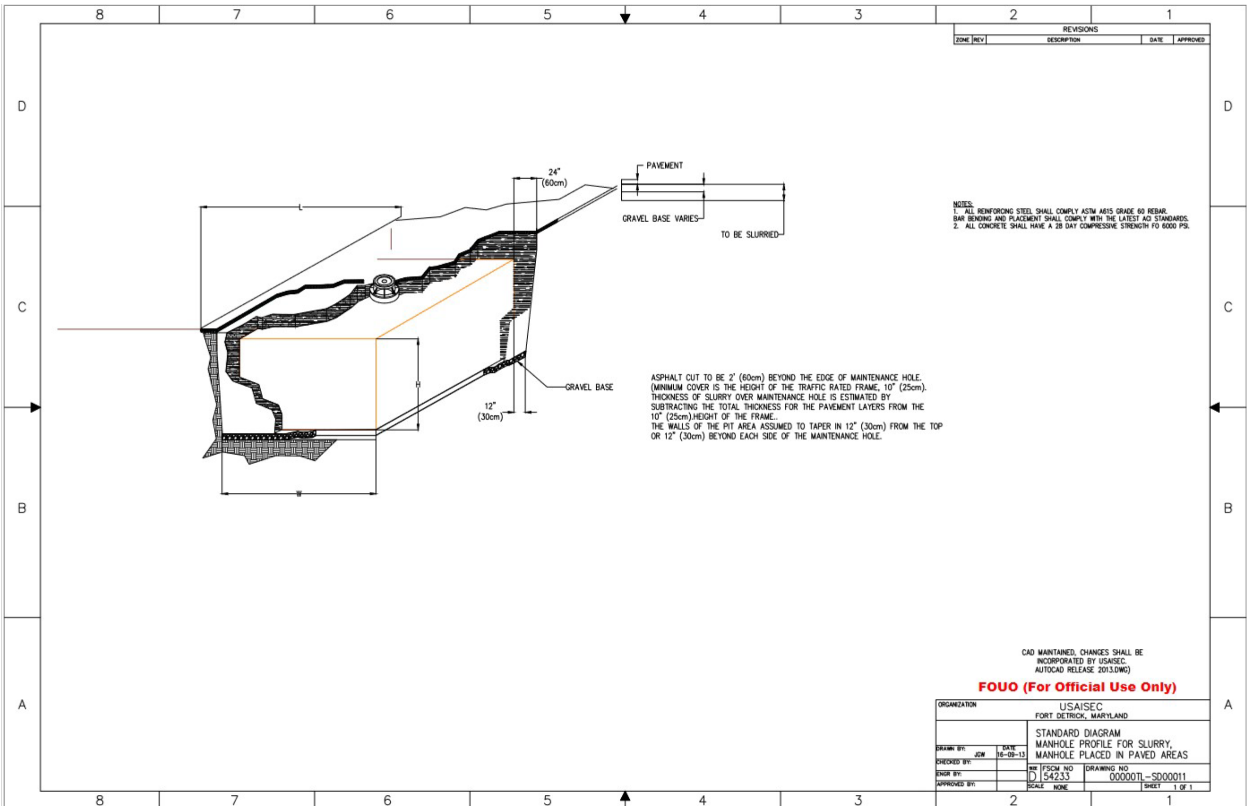


Figure A-16 Maintenance Hole Profile for Slurry, MH Placed in Paved Areas

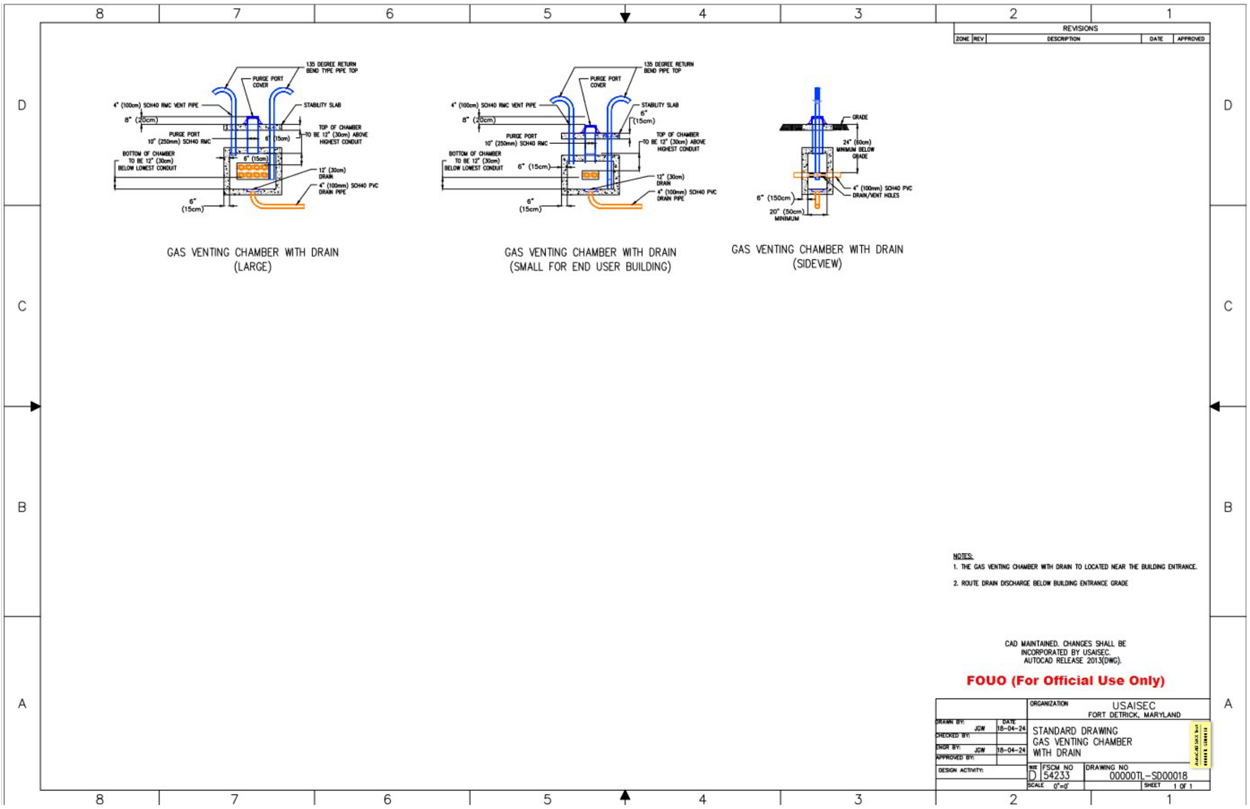


Figure A-17 Gas Venting Chamber with Drain

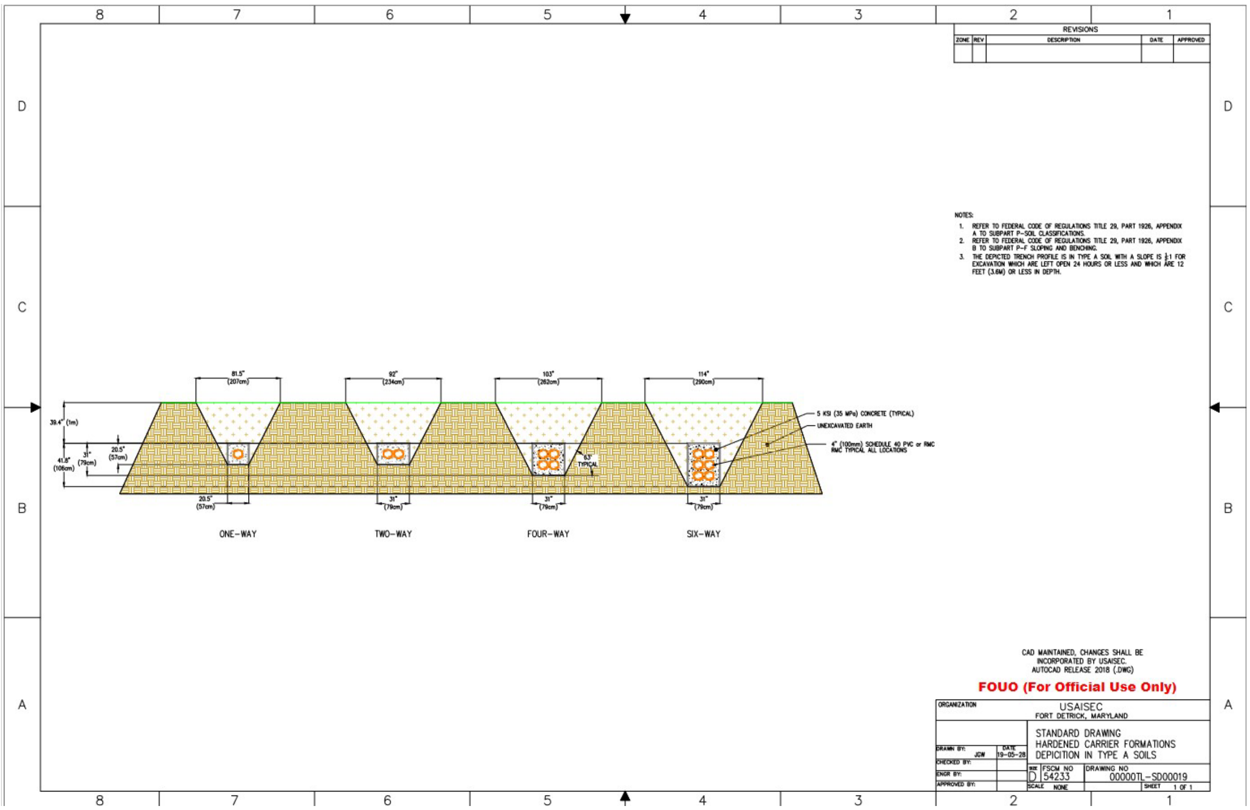
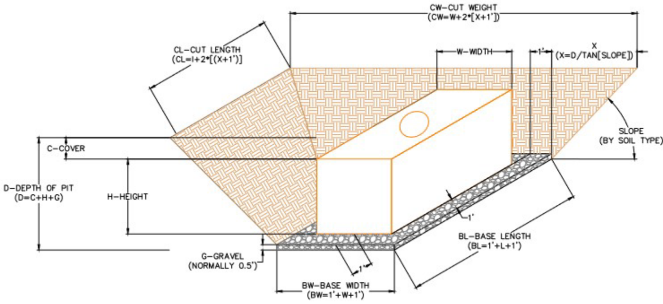


Figure A-18 Hardened Carrier Formations, Depiction in Type A Soils

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED



Maximum Allowable Slopes		
	Maximum allow slopes (H:V) for excavations less than 20 feet deep	
Soil or Rock Type	Hortizonatal:Vertical	Maximum slope angle
Stable Rock	Vertical	90°
Type A[1]	3/4:1	53°
Type B	1:1	45°
Type C	1.5:1	34°
Notes:		
1. A short-term maximum allowable slope of 1/2H:1V (63°) is allowed in excavations in Type A soil that are 12 feet (3.67m) or less in depth. Short-term maximum allowable slopes for excavations greater that 12 feet (3.67m) in depth shall be 3/4H:1V (53°).		
2. Meassure from grade to bottom of trench.		
3. Sloping or benching for excavations greater than 20 feet shall be designed by a registered professional engineer.		

SHORT TERM SIMPLE SLOPES

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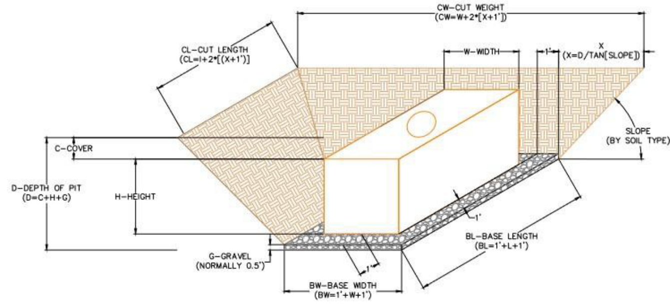
CHECKED BY:		SIZE D	FSCM NO 54233
ENGR BY:		DRAWING NO	00000TL-SD00020
APPROVED BY:		SCALE NONE	SHEET 1 OF 1

Figure A-19 Cuts for Maintenance Holes



Maximum Allowable Slopes		
	Maximum allow slopes (H:V) for excavations less than 20 feet deep	
Soil or Rock Type	Hortizonatal:Vertical	Maximum slope angle
Stable Rock	Vertical	90°
Type A[1]	3/4:1	53°
Type B	1:1	45°
Type C	1.5:1	34°
Notes:		
1. A short-term maximum allowable slope of 1/2H:1V (63°) is allowed in excavations in Type A soil that are 12 feet (3.67m) or less in depth. Short-term maximum allowable slopes for excavations greater that 12 feet (3.67m) in depth shall be 3/4H:1V (53°).		
2. Meassure from grade to bottom of trench.		
3. Sloping or benching for excavations greater than 20 feet shall be designed by a registered professional engineer.		

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ENGR BY:		SIZE D / FSCM NO 54233	DRAWING NO 00000TL-SD00020
APPROVED BY:		SCALE NONE	SHEET 1 OF 1

Figure A-20 Installation Details – Warning Tape

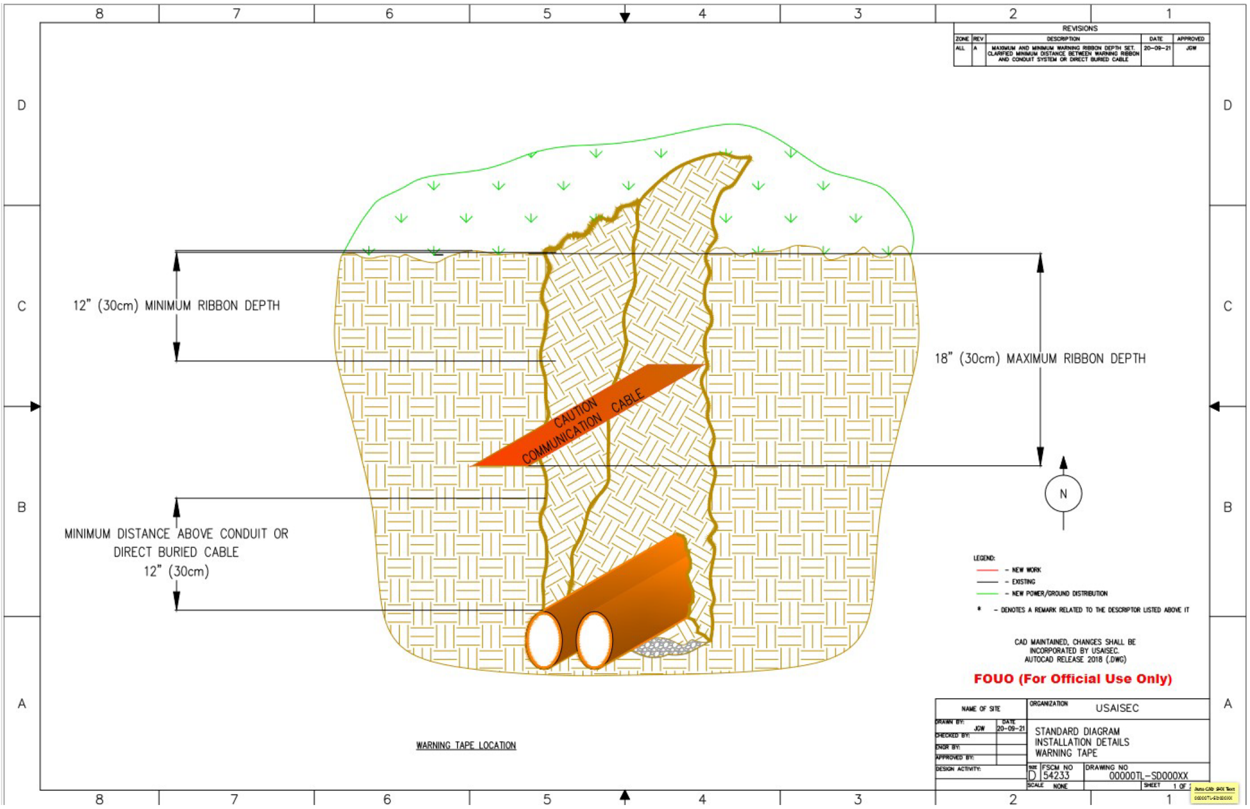


Figure A-21 Above Ground Building Entrances, Pullbox, and Conduit Bodies

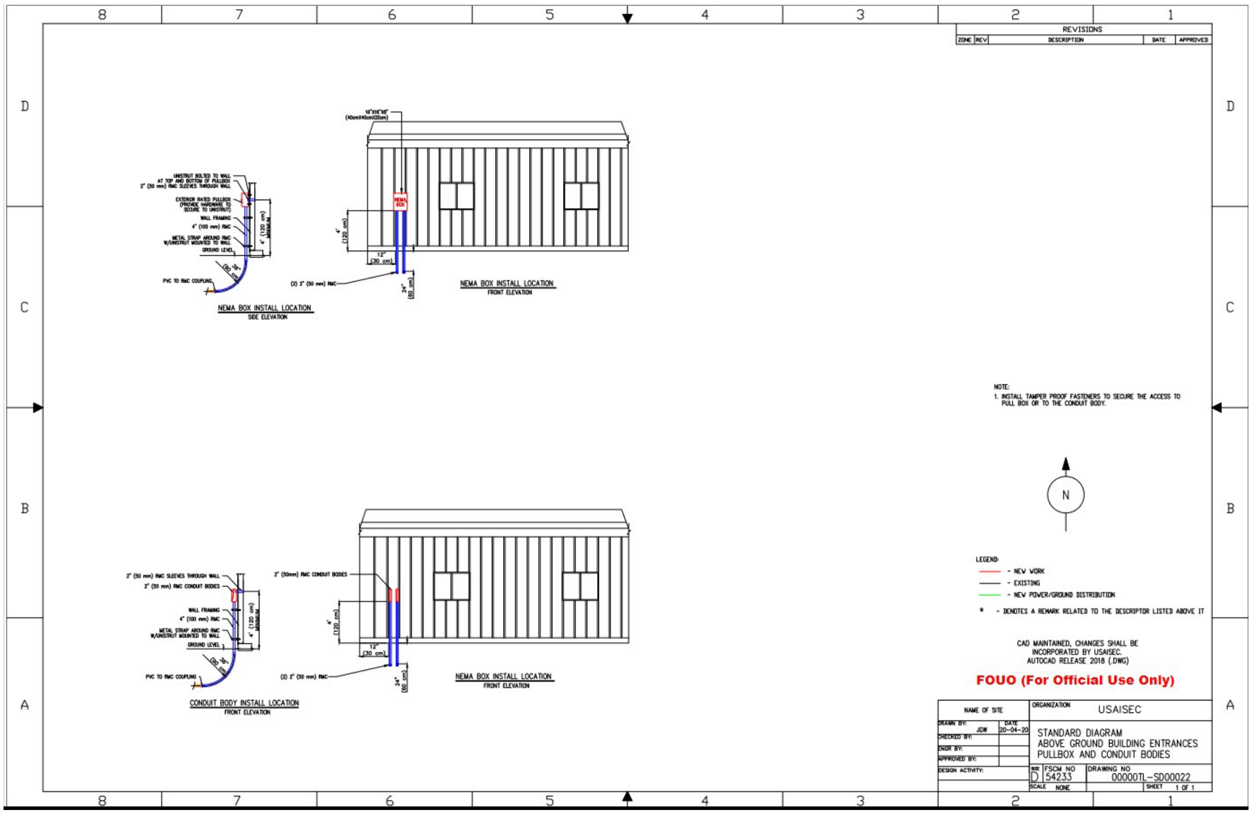


Figure A-22 Doweling to Repair Concrete Encased Conduit Systems

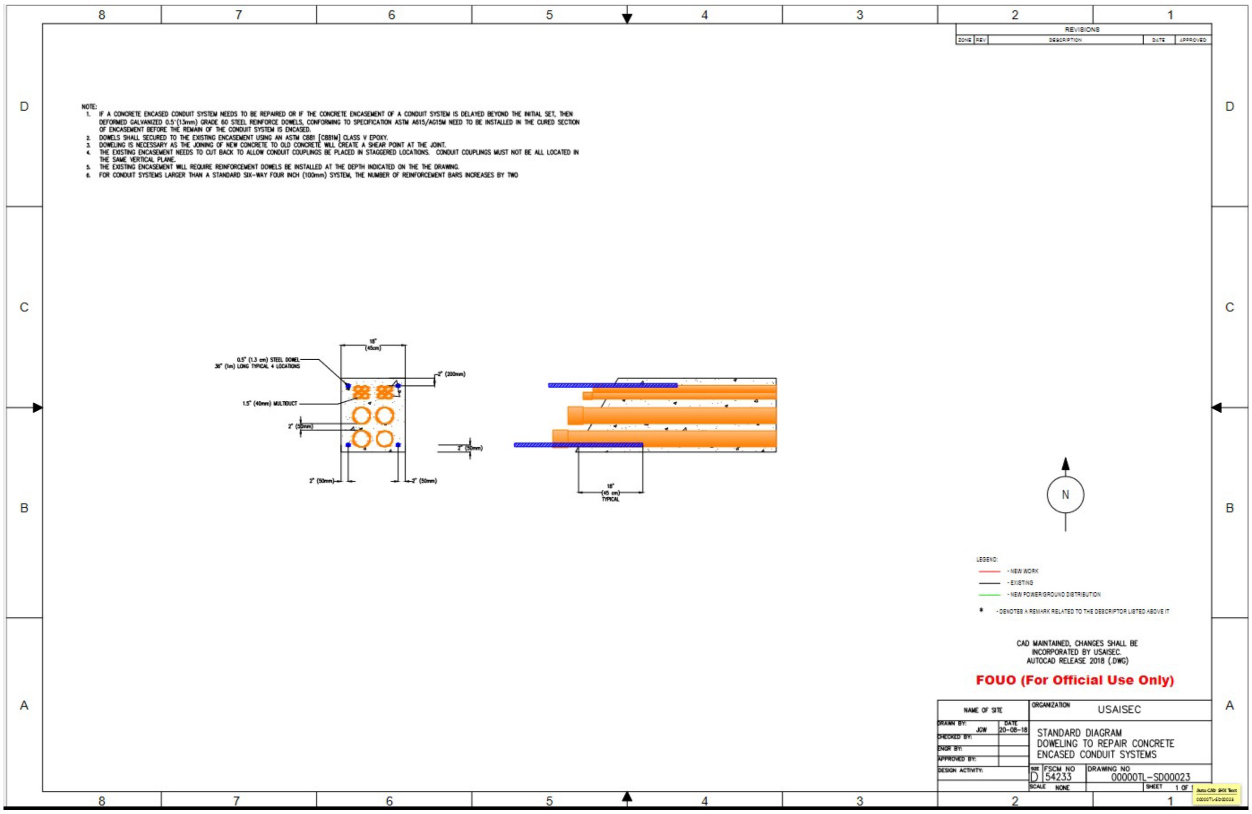


Figure A-23 Minimum Trench Depth for New Conduit Placement

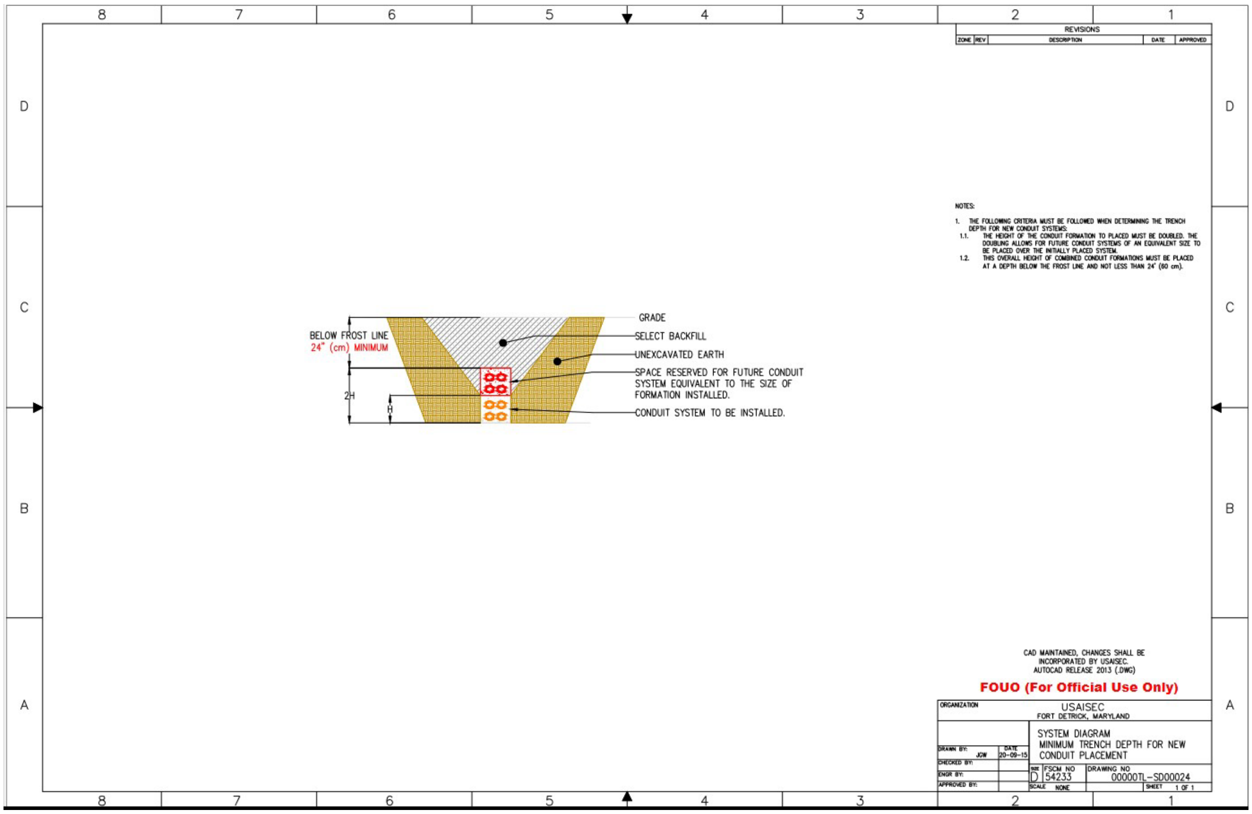
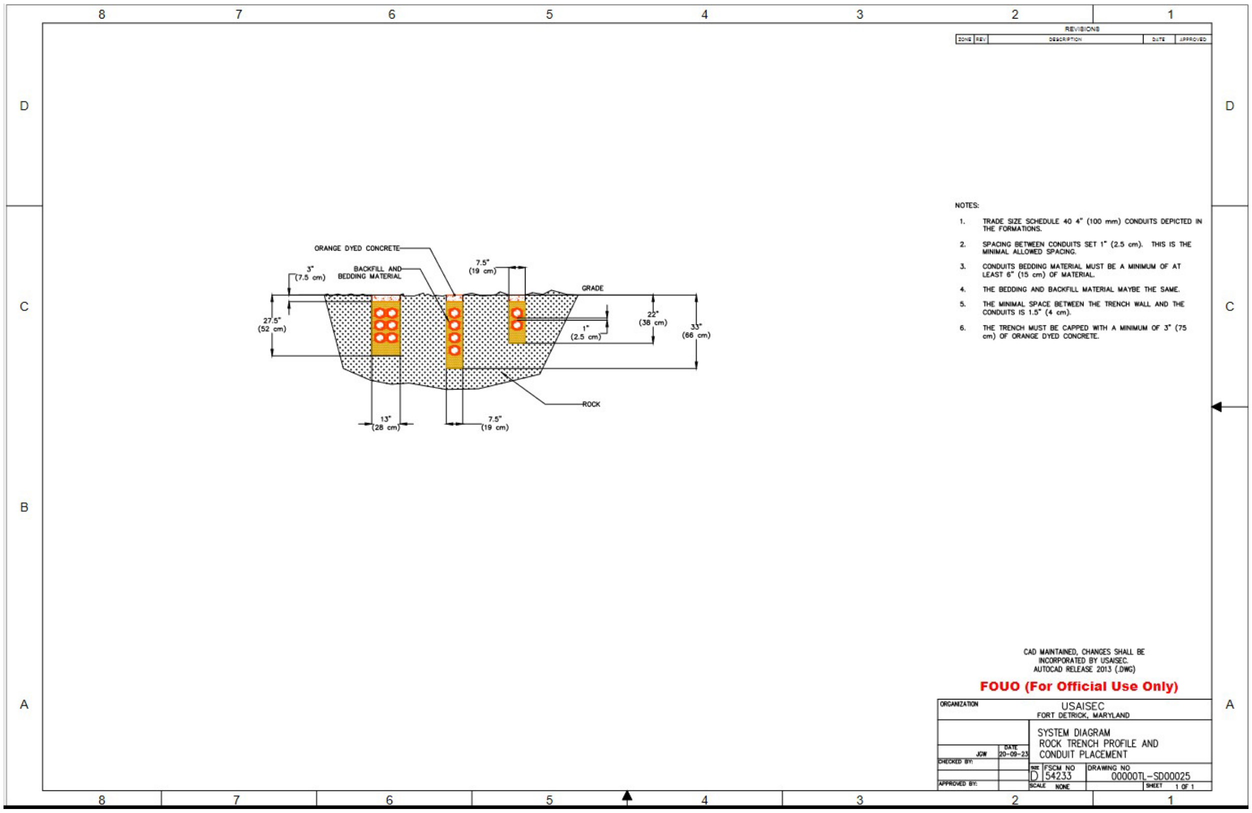


Figure A-24 Rock Trench Profile and Conduit Placement



APPENDIX B GLOSSARY

B-1 ABBREVIATIONS AND ACRONYMS.

µm	micrometer
10G-EPON	10 Gigabit per second Ethernet passive optical network
10G-PON	10 Gigabit per second passive optical network
8P8C	8-position, 8-contact
A	ampere
A/C	air conditioning
A/E	architect/engineer
A/V	audio visual
AASHTO	American Association of State Highway and Transportation Officials
ABF	air blown fiber
AC	alternating current
ACMS	Automated Control Management Sytem
ACPA	American Concrete Pipe Association
ADA	Americans with Disabilities Act
ADNCon	area distribution node
AFCEC	Air Force Civil Engineer Center
AFF	above the finished floor
AFH	Army Family Housing
AHJ	Authority Having Jurisdiction
ANSI	American National Standards Institute
APC	angle polished connector
APWA	American Public Works Association
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers

ASTM	American Society for Testing and Materials
AV	audio visual
AWG	American Wire Gauge
B/P/C/S	base/post/camps/stations
BAS	building automation systems
BATB	base area transport boundary
BBC	backbone bonding conductor
BCO	Base Communications Officer
BCT	bonding conductor for telecommunications
BD	building distributor
BEQ	Bachelor Enlisted Quarters
BET	building entrance terminals
BIA	Bilateral Infrastructure Agreements
BICSI	Building Industry Consulting Service, International, Inc.
BIM	Building Information Modeling
BMS	Building Management System
BNC	bayonet navy connector
BOQ	Bachelor Officers Quarters
BTS	base transceiver system
BTU/hr	British thermal units per hour
C4I	Command, Control, Communications, Computers, and Intelligence
CAT6A	Category 6A
CATV	community antenna or cable television
C-C	center-to-center
CCTV	closed-circuit television

CD	chromatic dispersion
CE	compromising emanations
CIC	cable in conduit
CNIC	Commander Navy Installations Command
CNSSAM	Committee on National Security Systems Advisory Memorandum
CNSSI	Committee on National Security Systems Instruction
CONUS	Continental United States
CP	consolidation point
CTTA	Certified TEMPEST Technical Authority
CV	cable vault
Cx	commissioning
CXA	Commissioning Agent
CXM	Commissioning Manager
DA	Department of the Army
DAA	Designated Accreditation Authority
DAQ	delivered audio quality
DAS	distributed antenna system
dB	decibel
DB	direct buried
dBmV	decibel millivolt
DC	direct current
DCO	Dial/Digital Central Office
DDC	direct digital controller
DIN	Deutsche Industrie-Normen
DISN	Defense Information System Network

DMFO	Defense Medical Facilities Office
DODIN	Department of Defense Information Network
DoN	Department of Navy
DOR	Designer of Record
DPW	Directorate of Public Works
DSN	Defense Switched Network
DWDM	dense wave division multiplexing
ED	edge device
EDFA	erbium-doped fiber amplifier
EES	earth electrode subsystem
EF	entrance facility
EIA	Electronic Industries Alliance
EOC	Emergency Operations Center
EPO	emergency power off
EPON	Ethernet passive optical network
ER	equipment room
ESS	enterprise survivable server
EUB	end user building
FACP	fire alarm control panel
fc	foot candle
FCC	Federal Communications Commission
FD	floor distributor
FEC	Facilities Engineering Command
FO	fiber-optic
FO/GO	Flag Officer/General Officer

FOC	fiber optic cable
FOCIS	Fiber Optic Connector Intermateability Standard
FOPP	fiber optic patch panel
FOUO	For Official Use Only
FRCS	Facility Related Control System
ft/s	feet per second
Gb	gigabit
GbE	gigabit Ethernet
Gbps	gigabit per second
GE	grounding equalizer
GEC	grounding electrode conductor
GFCI	ground fault circuit interrupter
GHz	gigahertz
GPON	gigabit passive optical network
GPR	ground penetrating radar
GSA	General Services Administration
HC	horizontal crossconnect
HCDS	hardened carrier distribution systems
HCP	horizontal connection point
HDCP	high definition copy protocol
HDD	horizontal directional drilling
HDMI	high definition multimedia interface
HDPE	high density polyethylene
HNFA	Host Nation Funded Construction Agreements
hp	horsepower

HVAC	heating, ventilation, and air conditioning
I3A	Installation Information Infrastructure Architecture
IC	integrated circuit
IC	intermediate crossconnect
ICAN	Installation and Campus Area Network
ICD	Intelligence Community Directive
ICDS	installation communications distribution system(s)
ICG	installation communications grid
ICS	industrial control system
ICT	information and communications technology
IDC	insulation displacement connector
IDF	intermediate distribution frame
IDS	intrusion detection system
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFC®	International Fire Code®
IMA	Information Mission Area
IMC	intermediate metallic conduit
IoT	Internet of Things
IP	internet protocol
IPN	installation processing node
IPS	intrusion prevention system
IPTV	internet protocol television
IS	information system
ISDN	Integrated Services Digital Network

ISN	installation servicing node
ISO	International Organization for Standardization
ISP	inside plant wiring
IT	information technology
ITE	information technology equipment
ITS	information transport system
ITU	International Telecommunications Union
ITU-T	International Telecommunication Union - Telecommunication Standardization Sector
JWICS	Joint Worldwide Intelligence Communications System
Km	kilometer
kPa	kilopascal
LAN	local area network
LATB	local area transport boundary
lb	pound
LC	lucent connector
LPS	limited power source
LSA	line-sharing adapter
LSA+	line-sharing adapter plus
LSPM	light source and power meter
LVDC	low voltage direct current
m/s	meters per second
mA	milliampere
MAC	moves, adds, and changes
MB	megabyte
Mb/s	megabit per second

MC	main crossconnect
MCEN	Marine Corps Enterprise Network
MCN	main communications node
MDF	main distribution frame
MH	maintenance holes
MHz	megahertz
MILCON	Military Construction
MIL-DTL	Military Detail
MIL-HDBK	Military Handbook
MIL-STD	Military Standard
MM	multi-mode
MPa	megapascal
MPD	metallic pedestal disconnect
MPTL	male plug terminated link
MTP®	Multi-fiber Termination Push-on
MT-RJ	mechanical transfer registered jack
MUTOA	multi-user telecommunication outlet assembly
N	Newton
NAVFAC	Naval Facilities Engineering Command
NCTAMS	Naval Computer and Telecommunications Area Master Station
NEC®	National Electrical Code®
NEC	network enterprise center
NEMA	National Electrical Manufacturers Association
NEN	Naval Enterprise Network
NESC®	National Electrical Safety Code®

NETCOM	U.S. Army Network Enterprise Technology Command
NFPA	National Fire Protection Association
NGEN	Next Generation Enterprise Network
nm	nanometer
NMCI	Navy and Marine Corps Intranet
NPCA	National Precast Concrete Association
NRTL	Nationally Recognized Testing Laboratory
NSANet	National Security Agency Intranet
NSC	network service center
NSI	National Security Information
NZDSF	non-zero dispersion-shifted fiber
OCONUS	outside of the continental United States
OLT	optical line terminal
OLTS	optical loss test sets
ONT	optical network terminal
OSHA	Occupational Safety and Health Administration
OSP	outside plant
OT	operational technology
OTDR	optical time domain reflectometer
OTN	optical transport node
P2P	peer-to-peer
PBB	primary bonding busbar
PBX	private branch exchange
PC	physical contact
PDS	protected distribution system

PE	polyethylene
PET	protected entrance terminal
PF	fluorinated ethylene propylene
PIC	plastic insulated cable
PM	Program Manager
PMD	polarization mode dispersion
POC	point of contact
PoDL	power over data line
PoE	power over Ethernet
POH	Power over HDBaseT
POL	passive optical local area network
PON	passive optical network
POTS	plain old telephone service
pr	pair
ps	picosecond
PSI	physical site identifier
psi	pounds per square inch
psi	pounds per square inch
PVC	polyvinyl chloride
PWD	Public Works Department
PWO	Public Works Office
QA	quality assurance
QC	quality control
RBB	rack bonding busbar
RC	Regional Coordinator

RCDD	Registered Communications Distribution Designer
RF	radio frequency
RGB	rack grounding busbar
RMC	rigid metallic conduit
ROICC	Resident Officer in Charge of Construction
RSC	rigid steel conduit
RTRC	red threaded fiberglass conduit/reinforced thermosetting resin conduit
RU	rack unit
RUS	Rural Utilities Service
SAPF	Special Access Program Facility
SBB	secondary bonding busbar
SC	standard connector
SCADA	Supervisory Control and Data Acquisition
SCIF	Sensitive Compartmented Information Facility
ScTP	screened twisted pair
SDAN	software defined access network
SDR	standard dimensional ratio
SEBQ	Senior Enlisted Bachelor Quarters
SFP	small form pluggable
SIDR	standard internal dimension ratio
SIPRNET	Secret Internet Protocol Router Network
SM	single-mode
SMF	single mode fiber
SOFA	Status of Forces Agreements
SPC	super personal computer

ST	subscriber terminal
STP	shielded twisted pair
TBB	telecommunications bonding backbone
TBC	telecommunications bonding conductor
TDM	time domain multiplexing
TDMM	Telecommunications Distribution Methods Manual
TE	telecommunications enclosure
TEBC	Telecommunications Equipment Bonding Conductor
TEF	telecommunications entrance facility
TEMPEST	Telecommunications Electronics Material Protected from Emanating Spurious Transmissions
TGB	telecommunications grounding busbar
TIA	Telecommunications Industry Association
TMGB	telecommunications main grounding busbar
TR	telecommunications room
TS	telecommunications space
TSB	Telecommunications Systems Bulletin
UCR	Unified Capabilities Requirements
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specification
UL	Underwriters Laboratory
UPC	ultra physical contact
UPS	uninterruptable power systems
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USG	U.S. Government

UTP	unshielded twisted pair
UXO	unexploded ordnance
VA	volt-amp
VAC	volts alternating current
VDC	volts direct current
VDE	Verband Deutscher Elektrotechniker
VTC	video teleconference
WAO	work area outlet
WAP	wireless access point
WIDS	wireless intrusion detection system
WLAN	wireless local area network

B-2 DEFINITION OF TERMS.

core node: On an installation (B/P/C/S), a core node (also referred to as a main communications node or area distribution node) is a physical location that typically hosts the commercial point of presence and serves as the aggregation point for the area distribution nodes.

intra-building backbone: Connectivity for the voice, video, and data networks between the entrance facility or equipment room, to a telecommunications room.

inter-building backbone: Connectivity between buildings, also referred to as part of outside plant (OSP).

ps: chromatic dispersion coefficient (Table 3-5)

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