Customer-Owned Outside Plant Telecommunications Infrastructure Standard

TIA-758-B
(Revision of TIA-758-A)

March 2012
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FOREWORD

(This foreword is not considered part of this Standard.)

This Standard was developed by TIA Subcommittee TR-42.4.

Approval of this Standard

This standard was approved by TIA Subcommittee TR 42.4, TIA Technical Engineering Committee TR-42, and the American National Standards Institute (ANSI).

ANSI/TIA reviews standards every 5 years. At that time, standards are reaffirmed, rescinded, or revised according to the submitted updates. Updates to be included in the next revision should be sent to the committee chair or to ANSI/TIA.

Contributing organizations

More than 70 organizations within the telecommunications industry contributed their expertise to the development of this Standard (including manufacturers, consultants, end users, and other organizations).

Documents superseded

This is the third issue of this Standard. This Standard replaces ANSI/TIA-758-A dated May 5, 2004.

Significant technical changes from previous edition

- Guidelines for the physical location and protection of below-ground cable plant have been added
- References are revised to the appropriate standards
- The annex referring to cabling lengths for specific applications is now referred to ANSI/TIA-568-C.0

Relationship to other TIA standards and documents

The following are related standards regarding various aspects of structured cabling that were developed and are maintained by Engineering Committee TIA TR-42. An illustrative diagram of the TIA-568-C Series relationship to other relevant TIA standards is given in figure 1.

- Generic Telecommunications Cabling for Customer Premises (ANSI/TIA-568-C.0)
- Commercial Building Telecommunications Cabling Standard (ANSI/TIA-568 C.1)
- Commercial Building Telecommunications Cabling Standard; Part 2: Balanced Twisted-Pair Cabling Components (ANSI/TIA 568 C.2)
- Optical Fiber Cabling Components Standard (ANSI/TIA-568 C.3)
- Commercial Building Standard for Telecommunications Pathways and Spaces (TIA 569 B)
- Residential Telecommunications Infrastructure Standard (ANSI/TIA 570 B)
- Administration Standard for Commercial Telecommunications Infrastructure (ANSI/TIA 606 A)
- Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications (ANSI J STD 607 A)
- Building Automation Systems Cabling Standard for Commercial Buildings (ANSI/TIA 862)
- Telecommunications Infrastructure Standard for Data Centers (ANSI/TIA 942)
- Telecommunications Infrastructure Standard for Industrial Premises (ANSI/TIA 1005)
Figure 1 – Illustrative relationship between the TIA-568-C Series and other relevant TIA standards

The following documents may be useful to the reader

a) National Electrical Safety Code®
   (IEEE C2)

b) National Electrical Code®
   (NFPA 70)

c) Building Officials and Code Administrators (BOCA)®:
   The BOCA Basic Building Code
Useful supplements to this Standard are the Building Industry Consulting Service International (BICSI) Telecommunications Distribution Methods Manual (TDMM), the Customer owned Outside Plant Methods Manual, and the Cabling Installation Manual. These manuals provide practices and methods by which many of the requirements of this Standard are implemented.

Other references are listed in annex C.

Annexes
Annex A and B are normative and considered as requirements of this Standard. Annex C is informative and not considered as requirements of this Standard.

Introduction
General
Telecommunications, as used in this Standard, refers to all forms of information (e.g., voice, data, video, alarm, environmental control, security, audio).

Purpose
The purpose of this Standard is to enable the planning and installation of an outside plant structured cabling system infrastructure.

This Standard establishes the recommendations and requirements used in the design of the telecommunication pathways and spaces, and the cabling installed between buildings or points in a customer-owned campus environment.

Customer-owned campus facilities are typically termed "outside plant" (OSP). For the purpose of this Standard they are termed, customer-owned OSP.

Stewardship
Telecommunications infrastructure affects raw material consumption. The infrastructure design and installation methods also influence product life and sustainability of electronic equipment life cycling. These aspects of telecommunications infrastructure impact our environment. Since building life cycles are typically planned for decades, technological electronic equipment upgrades are necessary. The telecommunications infrastructure design and installation process magnifies the need for sustainable infrastructures with respect to building life, electronic equipment life cycling and considerations of effects on environmental waste. Telecommunications designers are encouraged to research local building practices for a sustainable environment and conservation of fossil fuels as part of the design process.

Mandatory and advisory terms
In accordance with TIA Engineering Manual, two categories of criteria are specified; mandatory and advisory. The mandatory requirements are designated by the word "shall"; advisory requirements are designated by the words "should", "may", or "desirable", which are used interchangeably in this Standard.

Mandatory criterion generally applies to performance and compatibility requirements. Advisory criterion represents "above minimum" goals.

Metric equivalents of US customary units
The dimensions in this Standard are metric or US customary with soft conversion to the other.

Life of this Standard
This Standard is a living document. The criteria contained in this Standard are subject to revisions and updating as warranted by advances in building construction techniques and telecommunications technology.
1 SCOPE

This Standard specifies minimum requirements for customer-owned OSP telecommunications facilities in a campus environment. This standard specifies the cabling, pathways and spaces to support the cabling.

Customer-owned OSP cabling extends between separated structures including the terminating connecting hardware at or within the structures. The OSP pathway includes the pathway through the point of entry into the building space. Customer-owned OSP pathways may include aerial, direct-buried, underground (e.g., duct), and tunnel distribution techniques.

The OSP cabling specified by this Standard is intended to support a wide range of applications (e.g., voice, data, video, alarms, environmental control, security, audio) on commercial, industrial, institutional and residential sites.

This standard applies to all campuses, regardless of the size or population.

2 NORMATIVE REFERENCES

The following standards contain provisions that, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards published by them. ANSI and TIA maintain registers of currently valid national standards published by them.

a) ANSI O5.1.2008, Wood Poles - Specifications & Dimensions
b) ANSI/ICEA S-84-608-2007, Telecommunications Cable, Filled Polyolefin Insulated Copper Conductor
c) ANSI/ICEA S-85-625-2007, Aircore, Polyolefin Insulated, Copper Conductor Telecommunications Cable
d) ANSI/ICEA S-86-634-2004, Buried Distribution & Service Wire, Filled Polyolefin Insulated, Copper Conductor
e) ANSI/ICEA S-89-648-2006, Telecommunications Aerial Service Wire
f) ANSI/ICEA S-98-688-2006, Broadband Twisted Pair, Telecommunications Cable Aircore, Polyolefin Insulated Copper Conductors
g) ANSI/ICEA S-99-689-2006, Broadband Twisted Pair Telecommunications Cable Filled, Polyolefin Insulated Copper Conductors
h) ANSI-J-STD-607-A (2002), Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
i) ANSI/SCTE 15 2006, Specification for Trunk, Feeder and Distribution Coaxial Cable
l) ANSI/TIA-568-C.0 (2009), Generic Telecommunications Cabling for Customer Premises
m) ANSI/TIA-568-C.2 (2009), Balanced Twisted-Pair Telecommunications Cabling and Components Standard
n) ANSI/TIA-568-C.3 (2008), Optical Fiber Cabling Components Standard

r) Association of American Railroads (AAR), Recommended Practices for Communication Lines Crossing the Tracks of Railroads

s) ASTM B117-09, Standard Practice for Operating Salt Spray (Fog) Apparatus

t) ASTM C478-09, Standard Specification for Precast Reinforced Concrete Manhole Sections

u) ASTM C857-07, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures

v) ASTM C858-10, Standard Specification for Underground Precast Concrete Utility Structures

w) ASTM C890-06, Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures

x) ASTM C891-09, Standard Practice for Installation of Underground Precast Concrete Utility Structures

y) ASTM C913-08, Standard Specification for Precast Concrete Water and Wastewater Structures

z) ASTM C1037-08, Standard Practice for Inspection of Underground Precast Concrete Utility Structures

aa) ASTM C1433-10, Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers


cc) ASTM D635-10, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position


ff) NEMA TC 2-2003, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit

gg) NEMA TC 6 & 8-2003, Polyvinyl Chloride (PVC) Plastic Utilities for Underground Installations

hh) RUS Telecommunications Engineering and Construction Manual, Section 644, Number 03, Design and Construction of Underground Cable (1983)

ii) Telcordia GR-326 (2010), Generic Requirements for Single-Mode Optical Connectors and Jumper Assemblies

jj) Telcordia GR-771 (2008), Generic Requirements for Fiber Optic Splice Closures

kk) Telcordia GR-3151 (2007), Generic Requirements for Copper Splice Closures

ll) Telcordia TR-NWT-000979 (1991), Generic Requirements for Wire Connectors

mm) TIA-569-B (2004), Commercial Building Standard for Telecommunications Pathways and Spaces

nn) TIA-590-A (1997), Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant

oo) UL 497 Edition 7 (2009), Standard for Protectors for Paired-Conductor Communications Circuits
3 DEFINITION OF TERMS, ACRONYMS AND ABBREVIATIONS, AND UNITS OF MEASURE

3.1 General

The generic definitions in this clause have been formulated for use by the entire family of telecommunications infrastructure standards. Specific requirements are found in the normative clauses of this Standard.

3.2 Definitions

For the purposes of this Standard, the following definitions apply.

adapter: A device that enables, any or all of the following:

(1) different sizes or types of plugs to mate with one another or to fit into a telecommunications outlet,

(2) the rearrangement of leads,

(3) large cables with numerous conductors to fan out into smaller groups of conductors, and

(4) interconnection between cables.

administration: The method for labeling, identification, documentation and usage needed to implement moves, additions and changes of the telecommunications infrastructure.

aerial cable: Telecommunications cable installed on aerial supporting structures such as poles, sides of buildings, and other structures.

backbone: 1) A facility (e.g., pathway, cable or bonding conductor) for Cabling Subsystem 2 and Cabling Subsystem 3. 2) A facility (e.g., pathway, cable or conductors) between any of the following spaces: telecommunications rooms, telecommunications enclosures, common telecommunications rooms, floor serving terminals, entrance facilities, equipment rooms, and common equipment rooms. 3) in a data center, a facility (e.g. pathway, cable or conductors) between any of the following spaces: entrance rooms or spaces, main distribution areas, horizontal distribution areas, telecommunications rooms.

backbone cable: See backbone.

bonding: The permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed.

bridged tap: The multiple appearances of the same cable pair at several distribution points.

building backbone: Pathways or cabling between telecommunications service entrance rooms, equipment rooms, telecommunications rooms, or telecommunications enclosures within a building.

building entrance area: See entrance room or space (telecommunications).

buried cable: A cable installed under the surface of the ground in such a manner that it cannot be removed without disturbing the soil.

cabinet: A container that may enclose connection devices, terminations, apparatus, wiring, and equipment.

cabinet (telecommunications): An enclosure with a hinged cover used for terminating telecommunications cables, wiring and connection devices.

cable: An assembly of one or more insulated conductors or optical fibers, within an enveloping sheath.

cable sheath: A covering over the optical fiber or conductor assembly that may include one or more metallic members, strength members, or jackets.

cabling: A combination of all cables, jumpers, cords, and connecting hardware.

Cabling Subsystem 1: Cabling from the equipment outlet to Distributor A, Distributor B, or Distributor C.

Cabling Subsystem 2: Cabling between Distributor A and either Distributor B or Distributor C (if Distributor B is not implemented).
Cabling Subsystem 3: Cabling between Distributor B and Distributor C.

campus: The buildings and grounds having legal contiguous interconnection.

campus backbone: Cabling for interconnecting telecommunications spaces between buildings.

channel: The end-to-end transmission path between two points at which application-specific equipment is connected.

commercial building: A building or portion thereof that is intended for office use.

conduit: (1) A raceway of circular cross-section. (2) A structure containing one or more ducts.

conduit system: Any combination of ducts, conduits, maintenance holes, handholes and vaults joined to form an integrated whole.

connecting hardware: A device providing mechanical cable terminations.

cross-connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

cross-connection: A connection scheme between cabling runs, subsystems, and equipment using patch cords or jumpers that attach to connecting hardware on each end.

crossover: The junction unit at the point of intersection of two cable trays, raceways, or conduit (pathways) on different planes.

Distributor A: Optional connection facility that is cabled between the equipment outlet and Distributor B or Distributor C in a hierarchical star topology.

Distributor B: Optional intermediate connection facility that is cabled to Distributor C in a hierarchical star topology.

Distributor C: Central connection facility in a hierarchical star topology.

device, as related to protection: A protector, a protector mount, a protector unit, or a protector module.

direct-buried cable: A telecommunications cable designed to be installed under the surface of the earth, in direct contact with the soil.

distribution Pipeline: A gas pipeline other than a transmission gas pipeline.

duct: (1) A single enclosed raceway for conductors or cables. See also conduit, raceway. (2) A single enclosed raceway for wires or cables usually used in soil or concrete. (3) An enclosure in which air is moved. Generally part of the HVAC system of a building.

end user: The owner or user of the premises cabling system.

entrance facility (telecommunications): An entrance to a building for both public and private network service cables (including wireless) including the entrance point of the building and continuing to the entrance room or space.

entrance point (telecommunications): The point of emergence for telecommunications cabling through an exterior wall, a floor, or from a conduit.

excavation: Any operation in which earth, rock, or other material in the ground is moved, removed, or otherwise displaced by means of any tools, equipment, or explosives, and includes, but is not limited to, digging, augering, drilling, trenching, scraping, plowing, boring, or tunneling.

excavator: The person, company, or business that does the excavating.

excavation site: The specific location where excavation work is to be performed.

facility owner: The utility, firm, agency, or individual that is responsible for the fiber optic facility's operation and maintenance.

ground: A conducting connection, whether intentional or accidental, between an electrical circuit (e.g., telecommunications) or equipment and the earth, or to some conducting body that serves in place of earth.
grounding conductor: A conductor used to connect the grounding electrode to the building’s main grounding busbar.

handhole: A structure similar to a small maintenance hole in which it is expected that a person cannot enter to perform work.

infrastructure (telecommunications): A collection of those telecommunications components, excluding equipment, that together provide the basic support for the distribution of all information within a building or campus.

innerduct: A nonmetallic raceway, usually circular, placed within a larger raceway.

interconnection: A connection scheme that employs connecting hardware for the direct connection of a cable to another cable without a patch cord or jumper.

jumper: 1) An assembly of twisted-pairs without connectors, used to join telecommunications circuits/links at the cross-connect. 2) A length of optical fiber cable with a connector plug on each end.

link: A transmission path between two points, not including terminal equipment, work area cables, and equipment cables.

listed: Equipment included in a list published by an organization, acceptable to the authority having jurisdiction, that maintains periodic inspection of production of listed equipment, and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

maintenance hole (telecommunications): A vault located in the ground or earth as part of an underground duct system and used to facilitate placing, connectorization, and maintenance of cables as well as the placing of associated equipment, in which it is expected that a person will enter to perform work.

media (telecommunications): Wire, cable, or conductors used for telecommunications.

multimode optical fiber: An optical fiber that carries many paths of light.

optical fiber cable: An assembly consisting of one or more optical fibers.

outside plant: Telecommunications infrastructure designed for installation exterior to buildings.

patch cord: 1) A length of cable with a plug on one or both ends. 2) A length of optical fiber cable with a connector on each end.

patch panel: A connecting hardware system that facilitates cable termination and cabling administration using patch cords.

pathway: A facility for the placement of telecommunications cable.

pull tension: The pulling force that can be applied to a cable.

raceway: Any enclosed channel designed for holding wires or cables.

reinforced concrete: A type of construction in which steel (reinforcement) and concrete are combined, with the steel resisting tension and the concrete resisting compression.

service entrance: See entrance facility (telecommunications).

sheath: See cable sheath.

shield: A metallic layer placed around a conductor or group of conductors.

single-mode optical fiber: An optical fiber that carries only one path of light.

space (telecommunications): An area used for housing the installation and termination of telecommunications equipment and cable, e.g., common equipment rooms, equipment rooms, common telecommunications rooms, telecommunications rooms, telecommunications enclosures, work areas, and maintenance holes/handholes.

splice: A joining of conductors, meant to be permanent.
splice box: An enclosed space between pathways intended to house a cable splice.

splice closure: A device used to protect a splice.

star topology: A topology in which telecommunications cables are distributed from a central point.

support strand (messenger): A strength element used to carry the weight of the telecommunications cable.

telecommunications: Any transmission, emission, and reception of signs, signals, writings, images, and sounds, that is information of any nature by cable, radio, optical, or other electromagnetic systems.

telecommunications entrance facility: See entrance facility (telecommunications).

telecommunications entrance point: See entrance point (telecommunications).

telecommunications infrastructure: See infrastructure (telecommunications).

telecommunications media: See media (telecommunications).

telecommunications room: An enclosed architectural space designed to contain telecommunications equipment, cable terminations, or cross-connect cabling.

telecommunications service entrance: See entrance facility (telecommunications).

telecommunications space: See space (telecommunications).

terminal: (1) A point at which information may enter or leave a communications network. (2) The input-output associated equipment. (3) A device by means of which wires may be connected to each other.

termination position: A discrete element of connecting hardware where telecommunications conductors are terminated.

tip and ring: Respective designators for the positive (ground) conductor and negative (battery) conductor of a pair.

tolerance zone: The zone where excavation is to be performed with hand tools or nondestructive tools until the facility is exposed or the maximum depth of the intended excavation is reached. Damage prevention laws usually specify the location of this zone.

topology: The physical or logical arrangement of a telecommunications system.

transmission pipeline – A gas pipeline between storage and distribution facilities. A transmission pipeline usually operates at a pressure of 862 kPa (125 psi) or more, or at a hoop stress of 20 percent or more of its specified minimum yield strength regardless of its operating pressure.

underground cable: A telecommunications cable designed to be installed under the surface of the earth in a trough or duct that isolates the cable from direct contact with the soil.

utility tunnel: An enclosed passageway, usually placed between buildings, for the distribution of utility services.

wire: An individually insulated solid or stranded metallic conductor.

work area A building space where the occupants interact with telecommunications terminal equipment.

3.3 Acronyms and abbreviations

AASHTO American Association of State Highway and Transportation Officials
ADSL asymmetrical digital subscriber Line
AHJ authority having jurisdiction
ANSI American National Standards Institute
APWA American Public Works Association
AREMA American Railway Engineering Association
ASTM American Society for Testing and Materials
AWG American Wire Gauge
BBOSP Broadband Outside Plant
BOCA Building Officials and Code Administrators
BRI basic rate interface
CSA Canadian Standards Association International
EIA Electronic Industries Alliance
FCC Federal Communications Commission
FDDI fiber distributed data interface
FDU fiber distribution unit
FHWA Federal Highway Administration
FOCIS Fiber Optic Connector Intermateability Standard
HDSL high bit-rate digital subscriber line
ICEA Insulated Cable Engineers Association
IDC insulation displacement connector
IEC International Electrotechnical Commission
IEEE Institute of Electrical and Electronics Engineers
IHROW Interstate Highway Right-Of-Way
ISDN integrated services digital network
ISO International Organization for Standardization
LAN local area network
MH maintenance hole
MPD multiple plastic duct
NEC National Electrical Code
NEMA National Electrical Manufacturers Association
NESC National Electrical Safety Code
NFPA National Fire Protection Association
OC optical carrier
OCSI One-Call Systems International
OSHA Occupational Safety and Health Administration
OSP outside plant
OTDR optical time domain reflectometer
PCM pulse code modulation
PE Polyethylene
PVC polyvinyl chloride
RUS Rural Utilities Service
SCTE Society of Cable Telecommunications Engineers
289  SONET  Synchronous Optical Network
290  TDMM  Telecommunications Distribution Methods Manual
291  TIA  Telecommunications Industry Association
292  TSB  Telecommunications System Bulletin
293  UL  Underwriters Laboratories Inc
294  ULCC  Utility Location and Coordination Council
295  UTP  unshielded twisted-pair
296  UV  ultra-violet
297  VDSL  very high bit-rate digital subscriber line
298  X  cross-connect

299  3.4  Units of measure
300  dB  decibel
301  °C  degrees Celsius
302  °F  degrees Fahrenheit
303  ft  feet, foot
304  in  inch
305  km  kilometer
306  kPa  kilopascal
307  Mb/s  megabits per second
308  m  meter
309  mi  mile
310  mm  millimeter
311  psi  pounds per square inch
312  V  volt
313  µm  micron or micrometer
314  Ω  ohm

315  3.5  Symbols
316  See normative annex A for a partial list of OSP symbols.
4 CABLING INFRASTRUCTURE

4.1 General

The function of customer-owned OSP cabling infrastructure is to provide interconnections between building entrance facilities, structures on a campus, or telecommunications pedestals or cabinets. Customer-owned OSP cabling consists of the backbone cables, splices, terminations, and patch cords or jumpers used for backbone-to-backbone interconnection. The customer-owned OSP cabling infrastructure shall meet the requirements of the authority having jurisdiction (AHJ) and applicable codes.

4.2 Customer owned OSP cabling infrastructure overview

4.2.1 Pathways and spaces

Many types of pathways and spaces may be required to route cabling between campus buildings, structures, or outdoor telecommunications pedestal or cabinets. Figure 2 illustrates a variety of customer-owned OSP pathways and spaces. There are two basic types of cable pathway systems: underground and aerial (with exceptions for surface and above-ground conduit following the route of another above-ground utility).

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

Aerial pathways and spaces may consist of poles, messenger wire, anchoring guy wires, splice closures and terminals. Self-supporting cables, which include a messenger wire, may also be used.

4.2.2 Customer owned OSP cabling

Customer-owned OSP cabling consists of recognized cable terminated with conforming connecting hardware and protective devices, as required. Customer-owned OSP connecting hardware may be located on the exterior or interior of a building, or in an outdoor telecommunications pedestal or cabinet. Figure 2 illustrates a typical OSP cabling layout.

NOTES:

1 - The customer-owned OSP link can have intermediate splices (e.g., reducing a copper twisted-pair feeder cable to distribution cables).

2 - Optical fiber cables may pass through a building entrance facility as a part of the cable route. For example figure 3 shows a cable from building “C” passing through the building “A” entrance splice point location to the destination at the outdoor telecommunications pedestal “D”.

NOTES:

1 - The customer-owned OSP link can have intermediate splices (e.g., reducing a copper twisted-pair feeder cable to distribution cables).

2 - Optical fiber cables may pass through a building entrance facility as a part of the cable route. For example figure 3 shows a cable from building “C” passing through the building “A” entrance splice point location to the destination at the outdoor telecommunications pedestal “D”.
Figure 2 – Typical customer-owned OSP elements
Example of Campus

Symbols:
- Cable
- Fiber optic cable
- Cable splice

Notes:
1. This is a specific example, not all elements required
2. Protective device as required
3. Separate or mixed media connections

Figure 3 – Typical customer-owned OSP link
4.3 Topology

This standard establishes a structure for customer-owned OSP cabling based on the generic cabling system structure in ANSI/TIA-568-C.0.

Figure 4 illustrates an example of a campus with a star backbone topology. In this example, building “A” is the center of the star with backbone cables (part of Cabling Subsystem 2 or 3 in ANSI/TIA-568-C.0) extending to other campus buildings (“B, C, D, E, F”) and an outdoor telecommunications pedestal (“G”). This example also illustrates an optical fiber backbone cable passing from building “A” to building “F” through an intermediate building (“E”).

NOTES:

1 - An advantage of the star topology is that it provides the opportunity for centralized administration and management.

2 - In the example, Figure 4 shows building “A” providing a point of service for an up-link/microwave communications to a second campus. The backbone cables can be utilized for distributing these applications from “A” to all, or just selected buildings. If these services terminate at another building “B” versus “A”, the designer should size the backbone to extend these applications from “B” to “A”.

3 - Campus telecommunications applications require use of both building and campus backbone cabling. Figure 5 shows the relationship between the campus star backbone and the building backbones of building “E”. This illustrates the building cabling topology from an individual work area through the building backbone cabling to the campus backbone main interconnect facility in building “A”.

Although customer-owned OSP cabling in a star topology is advantageous, it may not always be feasible; the distances between buildings may exceed maximum allowable cable lengths. In these cases it may not be possible to cable the buildings in a star topology.

A large campus should be designed in a hierarchical star configuration. Each campus segment may connect to a hub location that would support the area as a star topology. These hub locations may be connected with other topologies to support equipment and technologies normally used for wide area applications (e.g., SONET, point-to-point microwave, leased lines).

Diversity should be provided where security, continuity of service, or other special needs exist.

4.3.1 Entrance point diversity

By developing diverse building entrance points, a catastrophic failure at one point around a building’s perimeter will not interrupt the entirety of the building’s telecommunications service. When entrance point diversity is developed, entrance points should be established distant from each other, preferably entering the building from two or more different streets.

4.3.2 Entrance route diversity

By developing diverse building entrance routes, a catastrophic failure along one entrance route will not interrupt the entirety of a building’s telecommunications service. When entrance route diversity is developed, entrance routes should be separated by the greatest possible distance.
Example of campus star topology

Symbols
Conductive cable
Fiber optic cable
Cable splice
Protective device (as required)
Termination

Notes:
(1) This is a specific example, not all elements required
(2) Protective device as required

Figure 4 – Example of campus star topology
Building “A”

Abbreviations

APS – Access Provider Space
CLEC – Competitive Local Exchange Carrier
CP – Consolidation Point
EF – Entrance Facility
ER – Equipment Room
IC – Intermediate Cross-connect
ILEC – Incumbent Local Exchange Carrier
MC – Main Cross-connect
MUTOA – Multi-User Telecommunications Outlet Assembly
SPS – Service Provider Space
TR – Telecommunications Room

Symbols

Conductive cable
Fiber optic cable
Cable splice
Protective device
(as required)
Cross-connect
Telecommunications Outlet

Figure 5 – Example campus/building cabling topology
4.4 Recognized Cabling

Customer-owned OSP cabling must support a wide range of services and site sizes. Therefore, more than one transmission medium is recognized. This standard specifies recognized transmission media that may be used individually or in combination. The recognized media include:

a) 100-ohm balanced twisted-pair cabling (ANSI/TIA-568-C.2);
b) multimode optical fiber cabling (ANSI/TIA-568-C.3);
c) single-mode optical fiber cabling (ANSI/TIA-568-C.3) optical fiber cable; and
d) 75 ohm coaxial (proposed ANSI/TIA-568-C.4).

The specific performance characteristics for recognized cables, associated connecting hardware, cross-connect jumpers and patch cords are specified herein.

4.5 Choosing media

Media choices must be made depending upon the characteristics of the applications, and distance. Where a single cable type may not satisfy all user requirements, it will be necessary to use more than one media type in the OSP cabling. Where possible, the different media should use the same physical pathway architecture and space for connecting hardware. In making this choice, factors to be considered include:

a) flexibility with respect to supported services;
b) required useful life of backbone cabling; and
c) site size and user population.

4.6 Bonding and grounding

Bonding and grounding systems are an integral part of the specific signal or telecommunications cabling system that they protect. In addition to helping protect personnel and equipment from hazardous voltages, a proper bonding and grounding system may reduce EMI to and from the telecommunications cabling. Improper bonding and grounding may allow propagation of induced voltages that could disrupt other telecommunications circuits.

Bonding and grounding shall meet the appropriate requirements and practices of applicable authorities and codes. Additionally, grounding and bonding within buildings shall conform to ANSI-J-STD-607-A requirements and the National Electrical Safety Code (NESC) between buildings.

Customer-owned OSP installation may be required to comply with additional higher level requirements. This may include military or commercial applications, or specific grounding and bonding practices not required by this standard, such as MIL-STD-188-124B-20018 DEC 2000.

4.7 Environmental Considerations

Environmental classifications have been developed for the purpose of describing areas in which cabling infrastructure is placed. The specifications of MICE include: M - mechanical; I - ingress; C - climatic; and, E - electromagnetic. Compatibility with the environment can be achieved with enhanced cabling components or through protection, separation or isolation. ANSI/TIA-568-C.0 provides thresholds for environmental conditions. MICE 1 ($M_1I_1C_1E_1$) generally relates to environmentally controlled areas such as commercial building offices, MICE 2 ($M_2I_2C_2E_2$) generally relates to a light industrial environment and MICE 3 ($M_3I_3C_3E_3$) generally relates to an industrial environment. The classification for areas with mixed environments may be described by including the classification level for each variable as a subscript (e.g., $M_{12}I_{12}C_{12}E_{12}$). If a cabling system component crosses an environmental boundary, the component or mitigation technique should be selected to be compatible with the worst case environment to which it is exposed.
5 PATHWAYS AND SPACES

5.1 Pathways

Telecommunications pathways are used to interconnect spaces such as buildings, pedestals, cabinets, maintenance holes, handholes, and towers. These pathways may consist of aerial, direct-buried, or underground, or a combination of these. Underground or direct-buried pathways are generally preferred over aerial pathways because of aesthetics and security. Of the two, underground pathways (e.g., conduits, ducts, etc.) are generally preferred over direct-buried because of security, ease of future cable installation and maintenance.

Telecommunications pathways shall be specified to support the initial and anticipated wireline and wireless telecommunications needs of the total area served. Accommodations should be made for diverse APs.

In determining the total number of pathways required, the planner shall consider:

a) type and use of building;

b) growth;

c) difficulty of adding pathways in the future;

d) alternate entrance; and

e) type and size of cables likely to be installed.

5.1.1 Subsurface pathways

5.1.1.1 General

Subsurface pathways shall meet applicable codes. In the absence of applicable codes, follow the most current version of the NESC. The following is a sample list of construction elements that need to be considered in the design and installation of subsurface pathways:

a) excavation;

b) clearances and separations from other utilities;

c) required depth;

d) buried street crossings;

e) encasing;

f) trenching;

g) boring (pipe pushing);

h) plowing;

i) backfill;

j) restoration;

k) horizontal directional drilling (HDD);

l) above ground obstructions; and

m) environmental considerations.

5.1.1.2 Conduit/duct

5.1.1.2.1 General

Underground conduit structures consists of pathways for the placements of telecommunications cable between points of access. Underground installation of ducts/conduits shall be achieved by trenching, boring, or plowing.
5.1.1.2.2 Conduit Type

Examples of conduit types include:

a) EB-20 – For encasement in concrete;
b) EB-35 – For encasement in concrete;
c) DB-60 – For direct burial or encasement in concrete;
d) DB-100 – For direct burial or encasement in concrete;
e) DB-120 – For direct burial or encasement in concrete;
f) Rigid Nonmetallic Conduit Schedule 40 – For direct burial or encasement in concrete;
g) Rigid Nonmetallic Conduit Schedule 80 – For direct burial or encasement in concrete;
h) Multiple Plastic Duct (MPD) – For direct burial or installation in conduit;
i) Rigid Metal Conduit (RMC) – For direct burial or encasement in concrete;
j) Intermediate Metal Conduit (IMC) – For direct burial or encasement in concrete;
k) Fiberglass Duct – For direct burial or encasement in concrete;
l) Innerduct Polyethylene (PE) – For direct burial or installation in conduit;
m) Innerduct Polyvinyl Chloride (PVC) – For direct burial or installation in conduit;
n) PVC coated steel conduit (PSC), NEMA RN-1; galvanized rigid steel conduit with factory applied external 40 mil PVC coating and urethane interior coating;

Encased buried (EB-20) and direct-buried (DB-60) conduit shall meet NEMA standard TC-6. Encased buried (EB-35) and direct-buried (DB-120) conduit shall meet NEMA standard TC-8. Schedule 40 and Schedule 80 Rigid Nonmetallic conduit shall meet NEMA standard TC-2.

Non-metallic conduits shall be encased in concrete of minimum 17225 kPa (2500 lb/in²) compressive strength where vehicular traffic (i.e., automotive, railway) is above the pathway, or where a bend or sweep in excess of 15 degrees is placed.

5.1.1.2.3 Lengths between pulling points

The section length of conduit shall not exceed 183 m (600 ft) between pulling points.

5.1.1.2.4 Bends

Where bends are required, manufactured bends should be used whenever possible. Bends made manually shall not reduce the internal diameter of the conduit. All bends shall be sweeps with a minimum radius of six times the internal diameter for conduits up to 2 inch and ten times the internal diameter for all conduits larger than 2 inch.

5.1.1.2.5 Number of bends

For the purposes of this sub-clause, the following definitions apply:

a) 90-Degree Bend: any radius bend in a piece of pipe that changes direction of the pipe 90-degrees.
b) Kick: a bend in a piece of pipe, usually less than 45-degrees, made to change the direction of the pipe.
c) Offset: two bends, usually having the same degree of bend, made to avoid an obstruction blocking the run of the pipe.
d) 90-Degree Sweep: a bend that exceeds the manufacturer’s standard size 90-degree bend; (e.g., 610 mm [24 in] is manufacturers standard for 102 mm [4 in] conduit and does not meet bend radius requirements) (resolved editorially).
e) **Back-to-back 90-degree Bend**: any two (2) 90-degree bends placed closer together than 3 m (10 ft) in a conduit run.

No section of conduit shall contain more than two 90-degree bends, or equivalent between pull points (e.g. handholes, maintenance holes, and vaults). If there is a reverse (U-shaped) bend in the section, a pull box shall be installed. Back-to-back 90-degree bends shall be avoided. Pull planning tools can assist in the design of a conduit system (e.g., RUS, Telecommunications Engineering and Standards Division 644 Issue #3, Design and Construction of Underground Cable, pulling lubricant manufacturer software).

### 5.1.1.2.6 Drain slope

Underground conduit should be installed such that a slope exists at all points of the run to allow drainage and prevent the accumulation of water. A drain slope of no less than 10 mm per meter (.125 in per foot) is desirable when extending conduit away from building structures. Where conduit extends between maintenance holes, a slope of 10 mm per meter (.125 in per foot) should extend from the middle of the span to each maintenance hole.

### 5.1.1.2.7 Innerduct

Innerduct (also known as subduct) is typically a nonmetallic or fabric mesh type pathway and may be placed within a duct to facilitate initial and subsequent placement of multiple cables in a single duct (see figure 6).

![Figure 6 – Example of innerduct](image)

### 5.1.1.2.8 Duct plugs

Ducts shall be sealed to resist liquid and gas infiltration at all maintenance holes and building entrance point locations.

### 5.1.1.2.9 Bridge crossings

The diversity of bridge construction makes it impracticable to prescribe a singular standard method for conduit placement. There are certain fundamentals to consider when placing conduit within or externally attached to these structures. Temperature variations require compensation for expansion and contraction of bridge structures. Even relatively small concrete structures have one or more floating spans.

Bridge crossings shall meet the requirements of the AHJ and applicable codes. The basic requirements for design are as follows:

a) Attachments to bridges shall be made with the approval of the AHJ.

b) Axial movement of up to 76 mm (3 in) at each expansion point should be compensated for by providing sliding joints (slip sleeves), either at a bridge abutment or a maintenance hole wall if the maintenance hole is in close proximity to the bridge.

c) Attachments should be flexible with each section being left with a provision for slight movement under load.

d) Conduit placement on the structure should be placed on the down-stream side of the structure and utilizing the structure for protection from floating debris in flood conditions.

e) The clearance of the conduit structure shall be no less than that of the bridge.
When routing requires crossing of bridged space, all placement methods should be considered in addition to incorporation into or attachment to the bridge structure. Catenary aerial construction, underwater crossing, and coffer dam stream bed construction are often viable crossing methods.

5.1.1.3 Utility tunnels

5.1.1.3.1 General

Utility tunnels are typically used for delivery of utilities such as electric, steam, water and telecommunications. Tunnels may be used as a telecommunications pathway for customer-owned OSP to interconnect buildings, or as a pathway to the property line. The telecommunications pathways within the tunnels may consist of duct, tray, or wireway. Cables placed in tunnels shall have the appropriate sheath properties for the environment and shall be clearly marked. See figure 7 for an example of components that may be found in a utility tunnel.

Figure 7 – An example of components that may be found in a utility tunnel.

5.1.1.3.2 Planning

Tunnels are planned for all utilities that they will house. The location of telecommunications pathways within a tunnel shall be planned to ensure accessibility and separation from other services. Telecommunications pathways in tunnels incorporate the following:

a) Corrosion-resistant pathways and associated hardware should be used.
b) Metal pathways shall be bonded per applicable code.
c) Separation from electrical facilities shall be per applicable code.
d) The pathway shall have the ability to withstand temperatures to which it may be exposed.
e) When used, pull boxes, splice boxes, and splice closures shall be readily accessible.

5.1.2 Direct-buried

Direct-buried cable is installed under the surface of the ground in such a manner that it cannot be removed without disturbing the soil. Direct burying of cable is achieved by trenching, boring or plowing. Those responsible for existing utilities shall be consulted when determining the cable route. Consideration should be given to the route, method of installation, terrain and landscape.

Suitable marking should be used to identify the location of the direct-buried cable and to protect the cable so that it is not inadvertently damaged during other construction activities.

5.1.3 Aerial pathways

5.1.3.1 General

An aerial facility consists of poles, support strand, cable and supporting hardware. Aerial cable is installed between supporting structures such as poles, buildings and other structures. Aerial cable is typically lashed to a cable-support strand (messenger). Aerial cable can also be supported by an integral support strand or a cable that has strength members providing load distribution.

Telecommunications aerial construction shall meet applicable codes, in the absence of applicable codes follow the NESC and ANSI O5.1. The following is a sample list of construction elements that need to be considered in the design and installation of aerial plant:

a) Pole class and length
b) Buried length of the pole
c) Guying of poles
d) Pole braces
e) Pole spacing
f) Slack span
g) Pole to building span
h) Grounding
i) Clearance and separation
j) Pole attachment
k) Lashing
l) Riser Protection
m) Messenger strand
n) Strand size and tension
o) Cable sag

5.2 Spaces

Spaces in OSP construction typically consist of maintenance holes, handholes, pedestals, cabinets, and vaults. Maintenance holes are typically used as points of access for pulling and splicing cable. Handholes are smaller than maintenance holes and are typically used as cable pulling points. Precast maintenance holes and handholes are generally placed in new construction. Pedestals are generally used to provide access to splices, interconnects and cable. Cabinets are used in buried and aerial construction as cross-connect points. Vaults provide grade level or below grade environmental protection, security and quick access to the splice cases, excess cable and distribution equipment.
5.2.1 Maintenance holes

5.2.1.1 General

Maintenance holes are concrete, steel or cast iron units provided with a removable lid that permits internal access via ladder or rungs to the housed components. They accommodate cable, splice closures, racking systems, and electronic equipment (e.g. environmental monitoring equipment, pumps). Maintenance holes shall be installed on a gravel base of sufficient depth to allow for drainage and stability. Where maintenance holes are installed in roadways, the lid (cover) shall support heavy vehicular traffic (See figure 8).

Maintenance holes are used to facilitate placing and splicing of cables. Maintenance holes shall be equipped with: corrosion-resistant cable racks, which are grounded; pulling irons; and a sump for drainage. Telecommunications maintenance holes shall not be shared with electrical installations other than those needed for telecommunications equipment.

Precast maintenance holes shall conform to the applicable ASTM standards:

ASTM C 478, Standard Specification for Precast Reinforced Concrete manhole Sections
ASTM C 789, Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers
ASTM C 850, Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers with Less Than 2 Ft of Cover Subjected to Highway Loadings
ASTM C 858, Standard Specification for Undergound Precast Concrete Utility Structures
ASTM C 890, Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures
ASTM C 891, Standard Practice for Installation of Underground Precast Concrete Utility Structures
ASTM C 913, Standard Specification for Precast Concrete Water and Wastewater Structures
ASTM C 1037, Standard Practice for Inspection of Underground Precast Concrete Utility Structures

Maintenance holes shall meet applicable code requirements. In the absence of applicable codes, follow the NESC. The following list is a sampling of maintenance hole construction items.

a) identification;
b) working height;
c) Size (LxWxH);
d) Covers and frames;
e) ladders;
f) sump-hole;
g) grounding rod;
h) exposed straps required for bonding to the grounding system as required by applicable electrical codes or practice for all metallic reinforcing members (e.g., ladders and cable racks).
Figure 8 – Example of maintenance hole

Figures courtesy of BICSI
5.2.1.2 Location

When determining maintenance hole locations, consideration should include ground topography, soil conditions, location of the maintenance hole relative to surrounding structures, personnel access, and the difficulty in using the maintenance hole for placing and splicing cable. Maintenance holes shall be placed when the conduit or duct section length exceeds 183 m (600 ft).

The recommended placement of maintenance holes in close proximity to intersections is placement within the right of way, but outside of the traveled portion of the street. Maintenance holes should not be placed within 15.2 m (50 ft) of the curb radius or right of way line of the intersecting road (See figure 9).

In determining the location of a maintenance hole at an intersection, consideration should be given to:

a) impaired traffic flow;
b) physical risk to telecommunications personnel during installation/maintenance operations;
c) physical risk to pedestrians due to impaired vision by themselves and drivers of vehicles;
d) risk of damage to telecommunications vehicles;
e) accessibility of maintenance holes during storm outage conditions; and
f) congestion of buried utilities in intersections.

Where maintenance holes are placed in the traveled portion of the road, the preferred location is 1.5 m (5 ft) from the curb.
5.2.1.3 Type

a) Type A — end-wall entrance only

b) Type B — see handhole (sub clause 4.2.2)

c) Type J — end and sidewall entrance

d) Type V — shaped like a V with one end-wall and two side-wall entrances

5.2.1.4 Sizing

The size of a maintenance hole shall be specified to include the ultimate duct structure capacity and the need for equipment located in the maintenance hole.
5.2.1.5 Covers

Maintenance hole covers shall meet the requirements of the environmental conditions of the location that they are placed. These include types for heavy vehicular traffic (e.g., type B, SB) and those for lighter loads (e.g., type R).

5.2.2 Handholes

5.2.2.1 General

Handholes are used to facilitate placing of cables in a conduit system. A handhole shall not be used in place of a maintenance hole or in a main conduit system. Splicing may be accommodated in handholes depending upon cable type and size. Handholes shall have provisions for drainage (e.g., drain holes, open bottom, sump-hole). Telecommunications handholes shall not be shared with electrical installations other than those needed for telecommunications equipment. (See figure 10)

Handholes shall meet applicable code requirements. In the absence of applicable codes, follow the NESC. The following list is a sampling of handhole construction items.

a) identification;
b) access;
c) covers.

Figure 10 – Handhole

5.2.2.2 Location

When determining handhole locations, considerations should include ground topography, soil conditions, location of the hole relative to surrounding structures, personnel access, and the difficulty in using the handhole for placing cable. Handholes may be placed when the bends exceed either two 90-degree bends or a total of 180-degrees; or the section length of conduit requires a pull point for ease of cable installation.

Conduit entering the handhole should be aligned on opposite walls of the hole at the same elevation.
5.2.2.3 Sizing
A handhole shall not exceed 1.2 m (4 ft) in length by 1.2 m (4 ft) in width by 1.2 m (4 ft) depth and should not be used in runs of more than three trade size 103 (trade size 4) conduits.

5.2.2.4 Covers
Handhole covers should be the same nominal size as the handhole.

5.2.3 Pedestals and cabinets

5.2.3.1 General
Pedestals and cabinets are the housings that store splice closures and terminals. They provide above grade environmental protection, security and quick access to splice closures, terminals, excess cable, and optical fiber equipment. Pedestals and cabinets may be mounted directly in the ground, on concrete pads, on mounting feet, on poles or floor stands.

These housings may include a locking device or hasp, adjustable mounting bracket or panel to secure taps, splitters, couplers, line extenders, amplifiers interdiction devices, hardware package, reels for cable storage, warning label, grounding and bonding provisions, identification, manufacturers markings, cable knockouts and grommets.

The following should be considered when selecting pedestals and cabinets:

a) cable bend radii > 15 times the cable diameter;
b) accommodate 4 cables;
c) accommodate both inline and butt splice closures;
d) security -- special bolts, keys and security alarm monitoring;
e) flood control provisions;
f) weather tight seals/gaskets/grommets;
g) optical fiber cable storage to permit moving the splice closure to a working location;
h) ventilation for environmental control and/or heat extraction (forced air fan optional);
i) resistant to rodent and insect intrusion;
j) environmentally controlled cabinets include fans, heaters and thermostats;
k) color options;
l) impact resistance (vandalism);
m) resistance to dust intrusion;
n) resistance to water spray; and
o) chemical resistance.

5.2.3.2 Ground level pedestals and cabinet criteria
Pedestals and cabinets shall meet the following criteria.

a) Corrosion resistance of metal components. ASTM B 117 salt spray test for (30) days;
b) Ultraviolet (UV) degradation of nonmetallic components. ASTM G 53 for (90 days - UVB-313 lamps);
c) Resistance to flame or fire RUS Specification PE-35;
d) Fungus resistance (ASTM 21);
e) UL Listed as type 3R (vented) or type 4 or 4x (non-vented); and
f) Grounding/Bonding provisions shall meet national and local electrical codes.
5.2.3.2.1 Installation requirements

Installation of pedestals should be such that water drainage will continue after the installation. In some instances the soil grading will be sufficient, while in other instances gravel may have to be placed in the bottom of the pedestal. The location of the pedestal should be away from traffic conditions that could cause injury to personnel, yet it should be easily accessible for maintenance.

5.2.3.3 Pole or wall mounted cabinets

Pole or wall mounted cabinets shall be constructed of corrosion resistant metal or nonmetallic materials. Access to the housed components is typically achieved through doors or removal of a portion of the housing. Special mounting brackets are used to secure cabinets to utility poles or building walls.

5.2.3.4 Environmentally controlled cabinets

Environmentally controlled cabinets are designed to provide a suitable environment for the satisfactory performance of electronic equipment. They typically provide for air circulation with fans and are thermostatically controlled for heating and cooling. The air conditioning units may be internally rack mounted or be physically attached to the exterior of the cabinet.

These cabinets should be corrosion resistant. Access to the splice case, optical fiber equipment and, in some cases, excess cable housed within is typically achieved through doors.

The surface mounted pedestals and cabinets are mounted either directly in the ground or on concrete pads.

5.2.4 Vaults

Vaults are open or closed bottom housings that provide grade level or below grade environmental protection, security and quick access to the splice cases, excess cable and distribution equipment.

The following should be considered when selecting vaults:

a) cable bend radii $\geq 15$ times the cable diameter;
b) accommodate 4 cables;
c) accommodate both inline and butt splice closures;
d) security -- special bolts, keys and security alarm monitoring;
e) flood control provisions;
f) stackable for shipping (vaults);
g) provisions for extensions to accommodate grade level changes (maintenance holes and vaults);
h) non-conductive and non-flammable materials;
i) provision to relocate without service interruption (vaults);
j) resistant to rodent and insect intrusion;
k) hardware for supporting closures and cable;
l) color options;
m) terminators or grommet provisions; and
n) skid resistant cover.

5.2.4.1 Vault criteria

Vaults shall meet the following criteria.

a) Corrosion resistance of metal components. ASTM B 117 salt spray test for (30) days;
b) Chemical resistance of nonmetallic components (gasoline, kerosene, acid/base etc.) ASTM D 543;
c) UV degradation of nonmetallic components. ASTM G 53 for (90 days - UVB-313 lamps); 

d) Resistance to flame or fire RUS Specification PE-35 or ASTM D 635; and,

e) Loading requirements

 i. Light duty (pedestrian traffic only), designed for protected areas only. (Test load 1361 kg [3000 lb] over 254 mm by 254 mm [10 in by 10 in] area with 13 mm [0.5 in] maximum deflection);

 ii. HS5, designed for sidewalk applications and for occasional non-deliberate traffic. (test load 5118 kg (11284 lb) over 254 mm by 254 mm [10 in by 10 in] area with 13 m [0.5 in] maximum deflection);

 iii. HS-10, designed for driveways, parking lots and off road application subject to occasional non-deliberate heavy vehicles. (test load 10 237 kg [22 568 lb.] over 254 mm by 254 mm [10 in by 10 in] area with 13 mm [0.5 in] maximum deflection); and,

 iv. HS-20, designed for deliberate heavy vehicular traffic.

5.2.4.2 Installation requirements 

Installation of vaults should be such that water drainage will continue after the installation. In some instances the soil grading will be sufficient, while in other instances gravel may have to be placed at specified depths. The vault may be located below grade, in which case locator stakes or location devices should be employed. The location of the vault should be away from traffic conditions that could cause injury to personnel, yet it should be easily accessible for maintenance.

5.2.5 Entrance Facilities

5.2.5.1 General

The entrance facility consists of the telecommunications service entrance to the building, including the entrance through the building wall, and continuing to the entrance room or space. The entrance facility may contain the building pathways that link to the equipment room or common equipment room (CER), and to other buildings in campus situations. Wireless device entrances may also constitute part of the entrance facility.

5.2.5.2 Seismic considerations

Specifications for entrance facilities shall accommodate the applicable seismic zone requirements.

5.2.5.3 Entrance location considerations

Consideration should be given to the facility, the occupants’ and users’ telecommunications wireline and the wireless connectivity needs. Where access to both wireline and wireless services is required, the entrance facilities may require adjustment in size, quantity, and location. Mechanical fixtures (e.g., piping, ductwork, pneumatic tubing) not related to the support of the entrance facility should not be installed in, pass through, or enter the telecommunications entrance facility.

Access providers and service providers shall be contacted to establish their requirements and explore alternatives for delivering service. The location of other utilities, such as electrical, water, gas, and sewer, shall be considered in the selection of the telecommunications entrance facility location.

Diverse entrance facilities should be provided where security, continuity of service, or other special needs exist.

When locating wireless transmission or reception device fields, line-of-sight interference and signal interference should be avoided.

5.3 Entrance pathway facilities

5.3.1 Underground

An underground facility is a component of the entrance facility consisting of conduit, duct, and trough, and may include maintenance hole(s) (see figure 11).
Underground entrance preplanning shall include land development, topographical limitations, and grading of underground facility to permit drainage. The facility may require venting of gaseous vapors. Vehicular traffic shall be considered in order to determine depth of cover over the facility and whether concrete encasement is necessary.

It is recommended that underground telecommunications facilities not be in the same vertical plane as other utilities, such as water or power that share the same trench. Utility services should be located horizontally with respect to each other, and shall be in compliance with applicable code.

**NOTES:**

1. Placing depth as required by local code.
3. Slope conduit towards maintenance hole.
4. Conduit ends to be plugged at time of placing (both ends).
5. Leave one or more spare duct from A-D, capped at A for future use.

**Figure 11 – Typical Underground entrance**

**5.3.2 Direct-buried**

A direct-buried facility is a component of the entrance facility where the telecommunications cables are completely encased in the earth. Direct burial is achieved by trenching, augering, boring, or plowing. The designer should consider that although direct-buried may be initially economical, the cable plant cannot be supplemented or replaced easily.

**5.3.3 Aerial**

An aerial facility is a component of the entrance facility consisting of poles, cable-support strand, and support system. When contemplating the use of aerial facilities, consider:

a) aesthetics of the building and surrounding location;
b) storm loading;
c) applicable codes;
d) clearances and separation (e.g. electrical, road, sidewalk);
e) mechanical protection;
f) span lengths;
g) building attachments;
h) future cable plant reinforcement; and
i) number of cables involved.

5.3.4 Tunnels

The service entrance to a building in a campus environment may be via a utility tunnel.

5.3.5 Wireless

5.3.5.1 Line of sight

Wireless transmission/reception device placement is critical to its performance. Obstructions to a wireless transmission/reception device function can take many forms including radio frequencies, electrical, and physical objects. Obstructions may be on the same platform, on an adjoining building, or be located some distance away. Wireless transmission/reception devices should be in line of sight with their target systems.

5.3.5.2 Cable pathways

Cable pathways from tower-mounted wireless transmission/reception devices should be consolidated where possible on the tower, and remain consolidated along their route to the access provider space. To limit the effect of signal strength reduction associated with excessive cable lengths, the most direct route between the wireless transmission/reception device and the entrance facility shall be followed. To protect cables from environmental damage and isolate cables from pedestrian traffic, they should be placed inside conduit or in cable tray, or be otherwise secured from physical damage.

5.3.5.3 Location

Depending upon function and site conditions, wireless service transmission/reception spaces may be located at the building’s upper rooftop, outside walls, or on lower roof setbacks. Wireless service transmission/reception points may also be located inside the building (e.g., behind windows). Wherever possible, wall-mounted wireless transmission/reception device support structures should be mounted at a minimum of 2 m (80 in) above surfaces where foot traffic may occur. Consideration should be given to prevention, where practicable, of signal interference resulting from vapor and heat shimmer.

5.3.5.4 Support structures

5.3.5.4.1 General

A structural engineer should be consulted in the design and placement of wireless transmission/reception device support structures.

5.3.5.4.2 Towers

Where the location or height of the building makes it a desirable wireless transmission/reception device site, consideration should be given to installation of a tower on the building roof. Towers are desirable because they allow efficient use of limited rooftop space, and offer significant flexibility regarding space planning. Multiple access providers and other users may share space on a single tower.

5.3.5.4.3 Non-penetrating wireless transmission/reception device mounts

Wireless transmission/reception devices that are of limited weight and size may be installed on mounts that are not fastened to the building structural members. These types of wireless transmission/reception device mounts are often referred to as sled mounts, ballast mounts, or non-penetrating wireless transmission/reception device mounts. These mounts remain secured to the rooftop by their own weight plus addition of dead weights to keep the wireless transmission/reception device in place. The amount of weight (ballast) required is calculated with consideration given to loading created by wind and ice buildup on the wireless transmission/reception device and supporting system. In some cases, these mounts are tethered for increased stability.
Penetrating wireless transmission/reception device mounts

Wireless transmission/reception device mounting systems that penetrate either the rooftop or walls of a building are commonly employed. The primary considerations with such systems are the loading that the system places on the structure, and waterproofing of any penetration points.

Electrical design considerations

Electrical service shall be sized to adequately provide power to equipment that may include, but is not limited to, wireless device lighting, de-icing, and motor-operated equipment. Where mandated by the AHJ, automatic switchover to standby power shall be provided. Electrical requirements should be specified by an electrical engineer, dependent upon the complexity of the installation.

Entrance point

General

An entrance point is the point of emergence of telecommunications cabling through an exterior wall, through a floor, or from a conduit.

Conduit entrance design guidelines

Conduit entrances consist of several metric designator 103 (trade size 4) conduits and, optionally, several metric designator 53 (trade size 2) conduits. In general, metric designator 53 (trade size 2) conduits should be considered for use with small diameter (e.g., 13 mm (0.5 in)) cables such as optical fiber and CATV cable, while metric designator 103 (trade size 4) conduit should be considered for use with larger diameter, multipair copper cables. An innerduct that is rated in accordance with AHJ may also be placed within metric designator 103 (trade size 4) conduit to facilitate smaller diameter cables such as optical fiber and coaxial cable.

As a minimum, three metric designator 103 (trade size 4), with at least one spare metric designator 103 (trade size 4), conduits shall be placed for each entrance point.

Penetration and termination

The conduit shall extend to undisturbed earth a minimum of 600 mm (24 in) beyond the exterior of the foundation (see figure 12 and figure 13). When terminated at the inside of the building wall, the conduit shall be reamed and bushed. When terminated at the inside of the building wall, the conduit shall have a smooth bell-shaped finish unless it extends to a remote entrance room, space, or area. The conduit or sleeve shall be securely fastened to the building.

NOTE – Some nonmetallic innerduct commonly used for underground or outside plant construction may not have the appropriate fire safety characteristics for use as a pathway within the building. Some non-metallic innerduct commonly used for underground or outside plant construction may be unlisted (not have the appropriate fire safety characteristics) for use as a pathway within the building.

Drainage

The conduit shall slope downwards towards the exterior (see figure 12). Where water infiltration is anticipated, an exterior drainage box shall be installed at the entrance point.

Gas, water and vermin

All conduits shall be plugged to restrict infiltration of gas, water, and vermin. To further ensure that gases do not enter the building, a venting system may need to be installed external to the building.

Pull box

A pull box shall be installed inside the building at the entrance point for cable pulling and splicing when:

- the building conduit is extended from the entrance conduit; or
- warranted by excessive conduit length; or
- the quantity of bends exceeds the equivalent of two 90 degree bends.
Pull boxes shall be provided in conduit building pathways as specified in ANSI/TIA-569-C. Pull box sizing shall be based on guidelines in ANSI/TIA-569-C.

Figure 12 – Example of entrance conduit or sleeve termination
NOTE: Slope sleeves downward 10 mm per m (0.125 in per ft) away from the building

Figure 13 – Encased entrance conduit termination
6 CABLING

6.1 Twisted-pair cabling

6.1.1 Twisted-pair cable

6.1.1.1 General

Covered herein are the requirements for multi-pair customer-owned OSP twisted-pair cables that are used in campus environments. The cables shall consist of 19 AWG (0.9 mm), 22 AWG (0.64 mm), 24 AWG (0.5 mm) or 26 AWG (0.4 mm) thermoplastic insulated solid copper conductors in one of the following designs. Specifications shall be crafted in a manner that directs the installation of customer-owned OSP telecommunications cables to be in accordance with the AHJ and applicable codes.

6.1.1.2 Cable performance


OSP cables are intended for the distribution of signals to carry voice and data. Enhanced performance BBOSP cables are intended for the distribution of signals to carry voice, high-speed data, and video.

6.1.1.3 Cable construction types

OSP and BBOSP cabling is installed in aerial, duct (underground), and direct-buried applications. The type of cable chosen for various installations should follow applications as given in table 1.

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>Aerial</th>
<th>Underground</th>
<th>Direct-buried</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filled</td>
<td>R¹</td>
<td>R²</td>
<td>R</td>
</tr>
<tr>
<td>Air Core</td>
<td>S</td>
<td>S²</td>
<td>N</td>
</tr>
</tbody>
</table>

R = Recommended
S = Suitable
N = Not Recommended

NOTES
1 - Both filled and air core OSP can be installed in the aerial plant providing the filled cable contains an 80°C (176°F) rated filling compound.
2 - When pressurized per sub-clause 6.4.
3 - A filled cable with cellular insulation is lighter and has a smaller diameter than a similar filled cable containing solid insulation.

6.1.1.4 Aerial (self-support and lashed)

Self-supporting cable shall incorporate an integral support messenger into the cable design. OSP cable intended for aerial use without a support messenger integrated into its design shall be lashed to a support messenger.

6.1.1.5 Buried service wire

Buried service wire is intended for use when extending from the distribution cable terminal to the entrance facility of a structure with limited cable needs. Buried service wire shall meet the requirements of ANSI/ICEA S-86-634. The maximum length of buried service wire shall not exceed 213 m (700 ft).
6.1.1.6 Aerial service wire

Aerial service wire is intended for use when extending from the distribution cable terminal to the entrance facility of a structure with limited cable needs. Aerial service wire shall meet the requirements of ANSI/ICEA S-89-648. The maximum length of aerial service wire shall not exceed 213 m (700 ft). The maximum span length shall not exceed 60 m (200 ft).

6.1.1.7 Screened cable (internally)

Internally screened OSP cable is intended primarily for use with pulse code modulation (PCM) transmission. One or more screens separate cable pairs within the core into compartments (i.e., one containing the transmit pairs, and the other the receive pairs) for improved crosstalk performance over conventional OSP cable. Screened cable shall meet the requirements of ANSI/ICEA S-84-608 for filled cable, and ANSI/ICEA S-85-625 for air core cable.

6.1.2 OSP connecting hardware for balanced twisted-pair cables

6.1.2.1 General

Specified herein are mechanical, environmental, and transmission performance requirements for connecting hardware for outside use that are consistent with the OSP twisted-pair cables described in sub clause 5.1.1. The connecting hardware includes terminal blocks that are used for transition from distribution cable to service wire, and cross-connect blocks that are used for cross-connection between feeder and distribution cables.

6.1.2.2 Environmental compatibility

Connecting hardware for OSP twisted-pair cabling shall be fully functional for continuous use within the temperature range of -40° C to 70° C (-40° F to 158° F). Means for connecting and removing wires shall be functional from -18° C to 50° C (0° F to 122° F). Terminals shall be resistant to corrosion from moisture and atmosphere, UV degradation, insecticides and herbicides.

6.1.2.3 Materials

Metal components shall be resistant to or protected against general corrosion and forms of localized corrosion, including stress corrosion cracking and pitting. They shall not produce significant galvanic corrosion effects, in wet or humid conditions, or on other metals likely to be present in pedestal terminal closures or aerial cable terminals.

Plastic parts shall be resistant to fungi, heat, solvents, and stress cracking agents, and be compatible with metals and other materials such as conductor insulation and filling compounds used in the manufacture of cable. Plastic materials shall be non-corrosive to metals and shall resist deterioration when exposed to chemical pollutants and sunlight.

6.1.2.4 Transmission

The transmission requirements of connecting hardware used in the OSP shall comply with connecting hardware requirements of ANSI/TIA-568-C.2.

6.1.2.5 Terminal block requirements

6.1.2.5.1 General

Terminal blocks provide a means to connect service wire to distribution cable. Terminals are provided with a means for connecting each terminal pair to the distribution cable, and a means for connecting the service wire to the terminal block. It is desirable that OSP terminal blocks be of the insulation displacement contact (IDC) type. Terminal blocks may have a stub cable to provide conductors between the terminal block and connection point to the cable. Terminal blocks are typically available in increments of 5- or 6-pair, from 5- to 50-pairs. Terminal blocks are used in a variety of environments, including flooding areas, and may be sealed to function when immersed in water. They are typically housed in an enclosure that is intended to shield the terminal block from moisture and sun exposure. The following requirements apply to connecting hardware used as terminal blocks in OSP.
6.1.2.5.2 Wire compatibility

Terminal blocks shall be compatible with the service wire used for an application. Service wire is available in 26, 24, 22, and 19 AWG copper and 18 1/2 AWG copper clad steel. The terminal block manufacturer shall designate the recommended wire gauges for each block. A terminal block shall meet electrical requirements for the smallest designated gauge after connecting and disconnecting the largest designated gauge.

6.1.2.5.3 Wire pair identification

A means for identifying individual terminal pairs shall be provided. In addition, the polarity of tip and ring of each pair shall be identified.

6.1.2.5.4 Test points

All terminal blocks shall allow access to test points for each pair without disconnecting the service wire from the terminal or puncturing the wire insulation.

NOTE – High impedance probes are needed to use the test access points for live high frequency applications.

6.1.2.5.5 Mounting

The terminal blocks shall be designed to allow secure fastening to a steel or plastic backboard. Required fasteners shall be provided.

6.1.2.5.6 Stub cable

When a stub cable is used to connect the terminal block to the distribution or feeder cable, the stub cable shall use standard color-coding to indicate individual pairs and tip and ring.

6.1.2.6 Cross-connect block requirements

6.1.2.6.1 General

Cross-connect blocks are used in OSP to connect feeder pair to distribution pair. They are typically located inside cross-connect cabinets, where a feeder cable(s) enter and one or more distribution cables exit. Each pair of the feeder cable is connected to a pair of contacts on a feeder cross-connect block. Each pair of the distribution cable is connected to a pair of contacts on a distribution cross-connect block. Feeder pairs are connected to distribution pairs with jumper wires between the feeder block and distribution block. It is desirable that cross-connect blocks for OSP cable pairs be of the IDC type. Cross-connect blocks are typically available in multiples of 10- or 25-pair. Cross-connect blocks in the outside environment are subjected to: temperature and humidity extremes; industrial or coastal atmospheres; and applied chemicals such as insecticides, herbicides, cleaners, and other solvents.

6.1.2.6.2 Wire compatibility

Cross-connect blocks shall be compatible with the feeder cable, distribution cable, and jumper wire used. Feeder and distribution cable is available in 26, 24, 22, and 19 AWG copper. Jumper wire may be 26, 24, or 22 AWG copper. The cross-connect block manufacturer shall designate the recommended cable and wire gauges for each block. A jumper connection to a cross-connect block shall meet electrical requirements for the smallest designated gauge after connecting and disconnecting the largest designated gauge.

6.1.2.6.3 Wire pair identification

Terminals shall locate tip on the left and ring on the right for horizontal spacing, or tip above the ring terminal for vertical spacing. A means for identifying individual terminal pairs shall be provided, either on the block or an adjacent surface. Removable red markers shall be available for attachment to a pair termination to designate special circuits. These markers shall withstand all environmental exposure required for the block without becoming unserviceable.
6.1.2.4 Wire termination
The cross-connect block shall be designed to eliminate the possibility of electrical shorts between any two terminals during jumper wire placement.

6.1.2.5 Test points
All terminals shall allow access to test points for each pair without disconnecting the jumper wire from the terminal or puncturing the wire insulation.

6.1.2.6 Terminal density
Terminals shall be arranged in a compact connecting hardware field consistent with the need to perform jumper operations.

6.1.2.7 Wiring harness
When a wiring harness is used to connect the cross-connect block to the distribution cable, the cable shall use standard color-coding to indicate individual pairs and to indicate tip and ring polarity.

6.1.2.7.1 General
Listed herein are the requirements for building entrance terminals located at the cabling entrance to building facilities where the transition between inside and outside environments occur. Outside terminals are typically used when the entrance connection is located in a closure on an outside wall of a building. Inside terminals are used when the outside cable will be connected to the inside distribution cabling system. Building entrance terminals are available in sizes such as 2-pair, 4-pair, 6-pair, and multiples of 10- and 25-pair. It is desirable that terminal blocks used for building entrance terminals be of the IDC type.

6.1.2.7.2 Non-protected terminals
Specifications for non-protected terminal connections inside the building are given in ANSI/TIA-568-C.2.

6.1.2.7.3 Protected terminals
Protected terminals shall meet the primary protection requirements of UL 497, the mechanical and reliability requirements of this Standard, and ANSI/TIA-568-C.2. In addition, the protected terminals shall meet the transmission requirements for the appropriate category of ANSI/TIA-568-C.2.

6.1.2.8 Splicing connectors
6.1.2.8.1 General
This specification describes characteristics and specifies requirements for hardware to splice OSP cables. Most splicing connectors use insulation displacement technology to allow efficient splicing of cables without stripping insulation. Single wire connectors (discrete) can be used to join or bridge tap (half-tap) one wire to a through wire and accommodate 26 through 19 AWG wire. Multiple pair connectors (modules) may be used to splice up to twenty-five wire pairs, and typically splice multiple wires, from 26 to 22 or 19 AWG. Both the discrete and multiple pair connectors shall be provided in both dry and moisture resistant forms for use in all OSP splicing environments (see figure 14 for examples of discrete and multiple pair connectors).
Figure 11 – Discrete and multiple pair connectors

Important characteristics of splicing connectors for OSP are consistently low connection resistance, high insulation resistance, robustness, resistance to moisture and corrosion, and ease of installation.

Connector manufacturers shall provide suitable application tooling and any auxiliary products that may be required to ensure the maintenance and reliability of the connectors in all OSP environments. The test sequence for splicing connectors is shown in table 2.

<table>
<thead>
<tr>
<th>Test</th>
<th>Group ID</th>
<th>Min Sample, contacts</th>
<th>Appendix Reference</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact resistance</td>
<td>A</td>
<td>100</td>
<td>A.2</td>
<td>IEC 512-2</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>A</td>
<td>100</td>
<td>A.3</td>
<td>IEC 512-2</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal shock</td>
<td>A&amp;B</td>
<td>100 each</td>
<td>A.6</td>
<td>IEC-68-2-14 TM Nb</td>
</tr>
<tr>
<td>Humidity/temperature cycle</td>
<td>A&amp;B</td>
<td>100 each</td>
<td>A.9</td>
<td>IEC-68-2-38 TM Z/AD</td>
</tr>
<tr>
<td>Vibration</td>
<td>D&amp;E</td>
<td>100 each</td>
<td>A.7</td>
<td>IEC 68-2-6 TM Fc</td>
</tr>
<tr>
<td>Stress relaxation</td>
<td>F&amp;G</td>
<td>100 each</td>
<td>A.8</td>
<td>IEC 68-2-14 TM Ba</td>
</tr>
<tr>
<td>Torsion</td>
<td>H&amp;J</td>
<td>10 each</td>
<td>A.10</td>
<td>Telcordia TR-NWT-979</td>
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<tr>
<td>Tensile strength</td>
<td>K&amp;L</td>
<td>12 each</td>
<td>A.11</td>
<td>Telcordia TR-NWT-979</td>
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<tr>
<td>Insulation resistance (immersion)</td>
<td>M&amp;N</td>
<td>100 each</td>
<td>A.12</td>
<td>Telcordia TR-NWT-979</td>
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<tr>
<td>Salt fog</td>
<td>P&amp;R</td>
<td>100 each</td>
<td>A.13</td>
<td>ASTM B117</td>
</tr>
<tr>
<td>Dielectric withstand voltage</td>
<td>S&amp;T</td>
<td>100 each</td>
<td>A.4</td>
<td>IEC 512-2 Test 4a Method C</td>
</tr>
</tbody>
</table>
6.1.2.8.2 Materials

Metal components shall be resistant to or protected against general corrosion and forms of localized corrosion, including stress corrosion cracking and pitting. They shall not produce significant galvanic corrosion effects, in wet or humid conditions, on other metals likely to be present in their use environment.

Insulating materials shall perform their designed electrical and mechanical functions and shall be resistant to fungi, heat, and cable cleaning solvents. They must be compatible with metals and other materials such as conductor insulation and filling compounds used in the manufacture of cable. Plastic materials shall be non-corrosive to metals and shall resist deterioration when exposed to chemical pollutants and sunlight.

All connector filling compounds and sealants shall be compatible with other connector and cable materials, and shall be resistant to fungi. They shall conform to safety and toxicology requirements at the time of manufacture.

Materials used for hand tools and for multiple wire connector splicing tools shall be compatible with other materials used in the environment.

6.1.2.8.3 Transmission

Markings on splicing hardware should include designation of transmission performance at the discretion of the manufacturer or the approval agency. The markings, if any, shall be visible during installation. It is suggested that the markings consist of:

- a) “Cat 3” for category 3 components
- b) “Cat 5” for category 5 components
- c) “Cat 5e” for category 5e components
- d) “Cat 6” for category 6 components
- e) “Cat 6A” for augmented category 6 components

6.1.2.8.4 Tensile strength

Tensile strength of a splice is established by measuring the force required to break the wire terminated in a splice connector when a load is applied axially to the wire in the direction of wire entry to the splice connector. This is compared to the breaking strength of an unspliced segment of the same wire. Minimum breaking strength for a spliced 19 AWG wire shall be 60 percent of 19 AWG wire breaking strength. Minimum breaking strength for spliced wires of smaller gauges shall be 75 percent of the control wire breaking strength.

6.1.2.8.5 Insulation resistance

Immersion testing is required for those devices that are intended to be designated for severe service conditions. Filled or moisture resistant connector samples shall be immersed in tap water for a period of one week. The insulation resistance shall then be measured between each conductor and the water bath with 250 V (dc) applied. Not more than 10 percent shall be less than $10^5 \Omega$, not more than 25 percent shall be less than $10^8 \Omega$ and the remainder shall be greater than $10^9 \Omega$. All samples shall be restorable to greater than $10^5 \Omega$ after drying. Those that fall below $10^8 \Omega$ shall be inspected for corrosion. The presence of corrosion is considered a failure.

6.1.2.8.6 Salt fog exposure

Terminated (or spliced) filled samples shall be exposed to salt fog per ASTM B 117 for a period of 48 hours. The resistance though each splice shall not increase by more than 2 m\(\Omega\) as a result of this exposure.
6.1.3 OSP twisted-pair cross-connect jumpers

Proper selection and installation of cross-connect jumper wire used between cross-connect blocks is essential to the overall performance of the network. Cross-connect jumper wire shall be wire of the same or higher transmission category as the cross-connect block. The twist shall be maintained to within 13 mm (0.5 in) of the entry into the cross-connect block.

6.1.4 Additional installation requirements

6.1.4.1 Cable splices for BBOSP

There are two types of splices as illustrated in figure 15. The butt splice method is preferred. An in-line splice method can also be used if the conductors are spaced close together, i.e., no open loops. The amount of untwisting of the conductor pairs shall be kept at 13 mm (0.5 in) maximum. This can be achieved by twisting the two conductors together after the splice is formed. For optimum performance, pair splices should be staggered within the splice closure.

![Butt splice and In-line splice](image)

Figure 12 – Example in-line and butt splice

6.1.4.2 Bridge-taps

While bridge-taps have been used for low frequency analog circuits, they are not recommended for OSP cabling. Bridge-taps can cause severe transmission impairment for high frequency digital circuits.

6.1.4.3 Binder group integrity

25-pair binder groups should not be split between connecting hardware points.

6.1.4.4 Cable bend radius

The minimum bend radius for non-gopher resistant OSP twisted-pair cable during installation shall not be less than 10 times the cable diameter, and after installation shall not be less than 8 times the cable diameter.

The minimum bend radius for gopher resistant OSP twisted-pair cable during installation shall not be less than 15 times the cable diameter, and after installation shall not be less than 10 times the cable diameter.

6.1.5 OSP twisted-pair testing

The basic field test parameters for OSP twisted-pair cabling are:

a) DC loop resistance
b) Wire map
c) Continuity to remote end
d) Shorts between two or more conductors
e) Crossed pairs
f) Reversed pairs
g) Split pairs
h) Any other mis-wiring
Additional test parameters to support high-speed digital or analog (i.e., VDSLx) services include:

- Capacitive Balance
- Attenuation to 18 MHz
- Longitudinal Balance to 18 MHz
- Metallic Noise to 18 MHz
- Impulse Noise to 18 MHz
- TDR test to identify & locate bad splices, splits, and bridged taps

6.2 Coaxial cabling

6.2.1 General

Coaxial cable used in backbone OSP applications is 75 Ω semi-rigid cable referred to as trunk, feeder and distribution coaxial cable. The cable is available in sizes ranging from 10 mm to 29 mm (0.412 in to 1.160 in) in diameter. Since attenuation is related to the diameter of the cable, larger cables are selected for longer installations or when it is desired to reduce the number of amplifiers in a link. 5/8-24 connecting hardware is available for each particular cable size. As outlined by ANSI/SCTE 92 2007 Specification for 5/8-24 Plug, (Male), Trunk and Distribution Connectors and ANSI/SCTE 91 2009 Specification for 5/8-24 RF & AC Equipment Port, Female. This cabling may be used in aerial, direct-buried or underground applications.

6.2.2 75 Ω coaxial cable

6.2.2.1 General

Mechanical and electrical requirements for 75 Ω trunk, feeder and distribution coaxial cable are found in the Society of Cable telecommunications Engineers (SCTE) document ANSI/SCTE 15 2006 Specification for Trunk, Feeder and Distribution Coaxial Cable. Requirements for both disc/air and foam dielectric cable designs are included in this document.

6.2.2.2 Cable performance

The cable shall meet requirements for mechanical and electrical transmission performance as specified in ANSI/SCTE 15 2006 Specification for Trunk, Feeder and Distribution Coaxial Cable.

6.2.3 75 Ω coaxial connecting hardware

6.2.3.1 General

5/8-24 connecting hardware is designed to fit each particular cable size and type. The cable manufacturer should provide information regarding connecting hardware that is compatible with the cable. Connecting hardware includes connector adapters, taps, splitters, amplifiers and directional couplers.

6.2.4 75 Ω coaxial cable installation requirements

Installation practices as described in SCTE document “Recommended Practices for Coaxial Cable Construction and Testing, Issue 1, Section 1” shall be followed.

6.2.5 75 Ω coaxial cable testing

The minimum test requirements for 75 Ω coaxial cable shall include a continuity test for the center conductor and shield. Due to the variety of designs encountered in OSP construction, it is not possible to establish link or channel requirements for these applications. The installer may test the following parameters; however, pass/fail criteria are not established by this Standard:

- Attenuation
- Length
- Characteristic impedance
d) Return loss

e) DC loop resistance

6.3 Optical fiber cabling

6.3.1 General

This sub-clause specifies requirements for an optical fiber cabling system (e.g., cable, connectors, splices, connecting and protective hardware, etc.) for customer-owned OSP. The recognized cables shall contain multimode fibers, single-mode fibers or a combination of these fiber types. For cables with both types of optical fibers, some means of segregating the fibers by type shall be employed. Requirements for bandwidth and system length should be considered before specifying the fiber type. Additionally, it is recommended that spare capacity be included to support present and future applications. As requirements for bandwidth continue to grow, consideration should be given to installing single-mode optical fiber in addition to multimode optical fiber.

6.3.2 Optical fiber cable performance

OSP optical fiber cable shall meet the performance requirements of ANSI/TIA-568-C.3.

6.3.3 Optical fiber cable construction types

OSP optical fiber cable shall meet the physical requirements of ANSI/TIA-568-C.3.

Optical fiber cables are available in several designs with many jacketing options. In many cases, a non-armored cable is referred to as a “duct” cable. An “all-dielectric” cable has no metallic or conductive components such as a metallic central member, metallic strength member(s), armor or copper wires.

6.3.3.1 Duct cables

Duct cables are generally non-armored cables. All-dielectric versions, which incorporate a nonmetallic central member, are available and are suitable for duct or conduit placement. These cables are ideal for duct, tunnel or aerial installations.

6.3.3.2 Armored cables

Armored cables are generally similar to duct cables, but have a steel armor layer added under the outer cable jacket. The armor is usually added to increase the rodent resistance of a direct-buried cable, however the armor also serves as an extra layer of protection against other factors, such as very rocky soil.

6.3.3.3 Aerial cables

Aerial cables typically have the same cable construction as duct cables. Self-supporting cables are typically duct cables with modifications to the duct cable design to simplify the aerial installation. All-dielectric optical cables are recommended in this application since these cables are not as susceptible to lightning strikes, are not subject to induced voltages and are not required to be grounded as are cables with metallic components.

6.3.3.3.1 Self-supporting cables

These cables are designed to be installed without the need for a pre-installed messenger. If properly installed, these cables can be installed in less time than lashing a conventional duct cable to a metallic messenger.

6.3.3.3.1.1 Figure 8 cables

These self-supporting cables incorporate a duct or armored cable and a messenger in a common sheath.

6.3.3.3.1.2 All-dielectric, self-supporting cables

These concentric cables have a duct cable core with a layer of strength members that allows installation without a separate messenger wire. Typically, there are length limitations depending upon location (due to the NESC wind and ice loading conditions), and special mounting hardware is required. As these cables are all-dielectric, no grounding is required.
6.3.3.4 Indoor/outdoor cables

Some cables are available that can be installed in both outdoor and indoor locations. These cables shall be water-blocked and UV resistant cables. The cable jackets are made of a flame retardant material which, allows the cables to pass the NEC flame test requirements for indoor installation and carry a cable flame rating (e.g., riser rated).

6.3.3.5 Drop cables

Drop cables are typically small diameter, low fiber count cables with limited unsupported span distances (when used in an aerial application). They are used to feed a small number of fibers from a higher fiber count cable into a single location.

6.3.4 Optical fiber connecting hardware

6.3.4.1 Optical fiber splicing

6.3.4.1.1 Splicing methods

Typical splicing methods include fusion and mechanical and are intended for use in a variety of environments such as in maintenance holes, utility vaults, aerial or open trench. Splicing may be used to join individual fibers (250 μm or 900 μm), fiber ribbons or ribbonized fibers.

6.3.4.1.1.1 Fusion splicing

Fusion splicing is a method of fusing two fibers together with an electric arc. Since the fibers are basically welded together, it is possible to get an environmentally stable optical fiber connection. For this reason, fusion splicing is recommended for optical fiber connections in the OSP.

6.3.4.1.1.2 Mechanical splicing

A typical mechanical splice (see figure 16) incorporates a gripping mechanism to prevent fiber separation, a means for fiber alignment, and includes index-matching gel. Depending on the design, the mechanical splices may be reusable. Because the mechanical splices depend on a physical contact between two cleaved fiber ends, these splices may be more sensitive to large variations in temperature.

![Figure 16 – Example of a mechanical splice](image)

Note: Dimensions are approximate

6.3.4.1.2 Attenuation

The splice optical insertion loss shall meet the performance requirements of ANSI/TIA-568-C.3.

6.3.4.1.3 Return loss

Splices shall meet the return loss performance requirements of ANSI/TIA-568-C.3.

6.3.4.1.4 Mechanical protection

Each fusion or mechanical splice shall be protected in a splice protection sleeve and splice tray or similar protective device that will mount inside a closure or an enclosure. The tray shall store and organize the fibers and splices, protect the fibers, and prevent the fibers from exceeding the minimum bend radius.
Stripped optical fiber should be protected with a heat shrink or silicone adhesive to prevent exposure to moisture.

### 6.3.4.2 Optical fiber connectors
Optical fiber connectors shall meet the requirements of ANSI/TIA-568-C.3. Care should be used in choosing the correct optical fiber connector for the intended environment.

### 6.3.5 Cabling Practices
OSP optical fiber cabling practices shall meet the requirements of ANSI/TIA-568-C.0.

### 6.3.6 Optical fiber patch cords and cross-connect jumpers
In environmentally conditioned spaces, patch cords and jumpers shall meet the requirements of ANSI/TIA-568-C.3.

### 6.3.7 Optical fiber cable installation requirements
The location and protection of the optical fiber cable shall comply with ANSI/TIA-590-A. All metallic components of the cable, except for metallic transmission media, shall be bonded to each other and to ground.

The minimum bend radius for OSP (including indoor/outdoor) shall meet the requirements according to ANSI/TIA-568-C.0.

### 6.3.8 Optical fiber cable testing
Testing of OSP optical fiber cabling shall be conducted according to ANSI/TIA-568-C.0.

### 6.3.9 Optical fiber inside terminals

#### 6.3.9.1 General
Optical fiber inside terminals shall meet the requirements of the ANSI/TIA-568-C.3 standard.

#### 6.3.9.2 Fiber storage and organizing housings
Fiber storage and organizing housings typically involve fiber and fiber splice storage, as well as fiber distribution and fiber cross connection.

The following should be considered when selecting fiber storage and housings:

a) Cable bend radii \( \geq 15 \) times the cable diameter;

b) Fiber bend radii \( \geq 38 \) mm (1.5 in);

c) Modular fiber connector loading provision to allow for expansion;

d) Vertical and horizontal cable accessibility for expansion;

e) Accommodate both 483 mm (19 in) and 584 mm (23 in) wide equipment racks;

f) Accommodate single sided wall mount available;

g) Cable entry ports providing for strain relief;

h) Provisions for electrically bonding/grounding cables; and

i) Storage for excess fiber slack.

Fiber distribution units featuring full front access may be used for restricted space installations.

#### 6.3.9.3 Fiber distribution units utilizing optical fiber connectors
These enclosures house and organize groups of fibers. Fibers are typically spliced to factory prepared connector pigtails that are loaded into patch panels. These splices are stored within the fiber distribution unit (FDU). Connections between cables are typically accomplished using connectorized jumpers.
6.3.9.4 Fiber distribution units utilizing fiber splicing techniques

The splice format FDU are used where higher performance connections are desired (lower insertion loss and lower back reflection). The enclosures house and organize groups of spliced fibers.

6.3.9.5 Fiber splice module housing

Splice module housings are used when directly splicing to the incoming fibers. Typically, these enclosures house and organize groups of fibers and accommodate splice trays, but have no patch panel capability.

6.4 Pressurization of air-core twisted pair cables

6.4.1 General

Air-core cable installed in subsurface pathways shall be pressurized. Air-core aerial cable should not be pressurized; rather, it should be vented.

Air pressure shall be maintained at any point along the cable route to a minimum of 1.5 psi plus 0.43 psi per foot of hydrostatic head (e.g., a cable is 2134 mm [7 ft] below the surface in a maintenance hole and the hole fills with water, there will be 7 times 0.43 [or 3 psi] of water pressure on the cable).

There are three basic types of cable pressurization: static pressure, a single feed system and a dual feed system. Dual feed systems are recommended. Dual feed systems pump air into the cables at different points along the cable route. In a dual feed system, pressurized air converges on a leak from both directions by supplying positive air pressure on both sides of the leak.

Where dry air pressure systems are deployed, consideration should be given to:

- a) cable manufacturer's recommendations;
- b) compressor size;
- c) dryer;
- d) manifolds, flow meters and cut-off valves;
- e) location of air feeds and air pipes;
- f) pneumatic resistance of the cable;
- g) monitoring system;
- h) alarm systems (e.g., transducers); and
- i) air plugs.
7 CABLING ENCLOSURES

7.1 General

Enclosures are used in OSP construction to enclose splices. These enclosures are commonly known as splice cases, or closures.

7.2 Materials

Metal components shall be resistant to or protected against general corrosion and forms of localized corrosion, including stress corrosion cracking and pitting. They shall not produce significant galvanic corrosion effects, in wet or humid conditions, on other metals likely to be present in pedestal terminal closures or aerial cable terminals.

Non-metallic components shall be appropriate to the environment in which they are installed. They should be resistant to fungi, heat, solvents, and stress cracking agents and compatible with metals and other materials such as conductor insulation and filling compounds used in the manufacture of cable. Non-metallic materials shall be non-corrosive to metals and shall resist deterioration when exposed to chemical pollutants and sunlight.

7.3 Copper twisted-pair splice closures

7.3.1 General

Closures protect copper splices from environmental hazards. Outdoor closures may be installed in pedestals, maintenance holes, and on poles and cable messenger strands.

The expected worst-case operating environment for a splice closure is described at temperatures between -40°C and 80°C (-40°F and 176°F). At these temperatures it is necessary that the closure not experience any functional degradation that could affect the performance of the closure. In addition, there are several extreme environmental and mechanical conditions to which a closure may be subjected in certain deployment configurations. These include flood water or chemical exposure, sub-immersion in ice, and exposure to steam or fire.

7.3.2 Common test for copper closures

Common tests for copper closures are referenced in Telcordia documents. These documents are listed in table 3.

Table 3 – References for copper closures common test methods

<table>
<thead>
<tr>
<th>Test</th>
<th>Test method reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonding and grounding</td>
<td>TR-NWT-000014</td>
</tr>
<tr>
<td>Metallic Corrosion &amp; Chemical Resistance</td>
<td>TR-NWT-000014</td>
</tr>
<tr>
<td>Nonmetallic Corrosion &amp; Chemical Resistance</td>
<td>TR-NWT-000014</td>
</tr>
<tr>
<td>Fungus Growth</td>
<td>TR-NWT-000251</td>
</tr>
</tbody>
</table>

7.3.3 Aerial copper closures/terminals

Aerial cable closures or terminals are housings constructed of either metallic or nonmetallic materials, varying in size and configuration to suit a variety of OSP applications. The basic functional objective of an aerial cable closure/terminal is to provide access to terminated cable pairs for the purpose of connecting service wires. The aerial cable closures/terminals are designed with internal facilities to accommodate splicing, connecting service wires for residential and business customers, bonding and grounding hardware and terminal block mounting arrangements. The housing provides for the appropriate entry of the cables from either or both ends.
7.3.3.1 Application
Aerial cable closures/terminals are intended for use on strand, pole or wall-mounted applications. Strand-mounted closures/terminals are designed for in-line installation, and some designs may be self-contained to fit over a sheath opening. Self-contained aerial cable terminals include a terminal block with a fusible-link stub cable for splicing to selected pairs of a distribution cable in a limited access splice chamber. The terminals of this terminal block may be accessible in a separate chamber where service drop wires may be connected.

Other aerial cable terminals may provide only a ready-access type of housing with a terminal block and fusible-link stub attachable to any of the distribution cable pairs. Some terminals intended for strand mounting may also be pole mounted, where, for example, a terminal is mounted at a dead end or at an aerial-to-buried transition.

Terminal blocks contained within the aerial cable terminal as well as those that are separate may contain mechanical integrity to support both the distribution cable and the aerial cable terminal. In addition, all metal supporting members and all electrical shields and ground wires of all terminals shall be electrically bonded so that hazardous voltages are directed to ground. For self-contained terminals, shield openings in the distribution cable shall be bridged by means of bond clamps and bonding wire assemblies. All bonding connections and members shall provide a current carrying capacity at least equivalent to that of #6 AWG wire.

7.3.3.2 Special testing
Special tests for aerial copper closures/terminals are referenced in Telecordia documents. These documents are listed in table 4.

Table 4 – References for aerial copper closures/terminals test methods

<table>
<thead>
<tr>
<th>Test</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt Fog</td>
<td>TR-NWT – 000014, Section 4.3.1, and 5.3.1</td>
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<tr>
<td>Ultra Violet Resistance</td>
<td>TR-NWT – 000014, Section 4.3.3, and 5.3.3</td>
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<tr>
<td>Weather-tightness</td>
<td>TR-NWT – 000014, Section 4.3.5, and 5.3.5</td>
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<tr>
<td>Water Intrusion Resistance</td>
<td>TR-NWT – 000014, Section 4.3.6, and 5.3.6</td>
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<tr>
<td>Hi Humidity Effects</td>
<td>TR-NWT – 000014, Section 4.3.7, and 5.3.7</td>
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<tr>
<td>Bond Clamp Pullout Test</td>
<td>TR-NWT – 000014, Section 4.4.1, and 5.4.1</td>
</tr>
<tr>
<td>Cable Pullout Test</td>
<td>TR-NWT – 000014, Section 4.4.2, and 5.4.2</td>
</tr>
<tr>
<td>Impact</td>
<td>TR-NWT – 000014, Section 4.4.3, and 5.4.3</td>
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<tr>
<td>Hinge Flexing</td>
<td>TR-NWT – 000014, Section 4.4.5, and 5.4.5</td>
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<tr>
<td>Seals and Gaskets, Thermal Aging</td>
<td>TR-NWT – 000014, Section 4.3.4, and 5.3.4</td>
</tr>
</tbody>
</table>

7.3.4 Buried service wire copper closures
Service wire splices are used to join lengths of underground service wire. The splice and closure shall be compatible with the wires. The splice and closure shall maintain the mechanical, electrical, and environmental characteristics for forty years.

7.3.4.1 Application
Buried service wire closures shall mitigate problems of external and internal water. Protection is to be provided by sealing all entering cables and drop wires in a shell without the use of secondary encapsulants for protection. However, the materials used should be compatible with encapsulants so that they may be used as secondary protection if desired. All of the component sealants and parts shall be compatible with petroleum jelly and other types of filling compounds.
7.3.4.2 Special tests

Special tests for buried service wire copper closures are referenced in Telcordia document TR-NWT-000251. See table 5.

<table>
<thead>
<tr>
<th>Test</th>
<th>Test method</th>
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<tr>
<td>Cable Pullout</td>
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<td>Torsion Resistance</td>
<td>TR-NWT-000251, Section 4.1.5, and 5.1.5</td>
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<tr>
<td>Bending Resistance</td>
<td>TR-NWT-000251, Section 4.1.6, and 5.1.6</td>
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<td>TR-NWT-000251, Section 4.2.2, and 5.2.2</td>
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<td>TR-NWT-000251, Section 4.3.3.1, and 5.3.3.1</td>
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<td>Drop Test</td>
<td>TR-NWT-000251, Section 4.3.3.2, and 5.3.3.2</td>
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<tr>
<td>Water Immersion</td>
<td>TR-NWT-000251, Section 4.3.5, and 5.3.5.1</td>
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<tr>
<td>Thermal Shock</td>
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</tr>
<tr>
<td>Freeze/Thaw Cycling in Wet Sand</td>
<td>TR-NWT-000251, Section 4.3.6, and 5.3.6</td>
</tr>
<tr>
<td>Water Head</td>
<td>TR-NWT-000251, Section 4.3.7, and 5.3.7</td>
</tr>
<tr>
<td>Sealant (Encapsulant)</td>
<td>TR-NWT-000251, Section 4.3.8, and 5.3.8</td>
</tr>
</tbody>
</table>

7.3.5 Buried/underground/vault copper splice closures

A splice closure provides the means to restore integrity of the cable sheath following a sheath opening for the purpose of wire joining, installation of an isolation gap, capacitor, pressure dam, the repair of a damaged sheath, or the closing of initial gaps between sheaths at splice points. The splice closure must restore the cable sheath's electrical and mechanical properties. For the purpose of this Standard, the term splice closure shall include bonding hardware, sealing materials and the closure housing. Waterproof splice closures are used primarily to enclose cable in direct-buried and underground applications.

7.3.5.1 Splice configurations

Splice closures are classified according to the configurations that cables may enter the closure, as follows:

a) Straight - an opening is provided for only one cable to enter each end of the closure.
b) Branch - openings are provided for two cables to enter each end of the closure.
c) Butt - openings are provided such that two cables enter one end of the closure and no cable enters the other end of the closure.
d) Special application - opening adapters are provided to allow multiple cable entry.

7.3.5.2 Closure housing

The closure housing shall be compatible with all materials used in the construction of cable, filling compounds, bonding and grounding devices, chemicals, and sealants, which the closure would contact under normal use. Secondary corrosion protection should not be required.

7.3.5.3 Installation requirements

The closure construction (e.g., size, weight) and installation procedures shall be suitable for handling by one crafts person. On-site assembly or disassembly of the closure prior to installation should be minimized. Bonding, grounding and other sub-assemblies where practical should be factory assembled. The closure should be installed to allow re-entering without destruction of the housing unless such destruction is economically justified. If reusable, the closure components should be immediately reusable, without factory or service center refurbishing and with minimum field rehabilitation work. The use of specialized tools or equipment not normally at crafts person's disposal should be avoided, unless for protection from tampering.
The following should be considered when selecting splice closures:

1. A closure or series of closures should be suitable for installation over cut or through (uncut) cable, and usable on 254 mm to 533 mm (10 in to 21 in) sheath openings (but not necessarily limited to these openings).

2. The series of closures should accept cables of 15 mm to 86 mm (0.6 in to 3.4 in) OD, and have splice cavity diameters from 25 mm to 228 mm (1 in to 9 in) (or equivalent cross-sectional areas if not round).

3. The closures should be usable for straight, branch or butt splice configurations.

4. Replacement and special application parts shall be readily available.

5. The use of specially-ordered non-catalog stock parts should be avoided.

6. All sizes of the closure and its intended encapsulant as system must not generate any exothermic condition that will damage the housing, cable insulation or connectors.

7. The closure housing shall be sufficiently sealed to prevent encapsulant leakage. Provisions shall be made which will indicate that the closure is properly filled with encapsulant after the encapsulant has cured.

7.3.5.4 Special tests

Special tests for buried/underground/vault copper splice closures are referenced in Telcordia documents. These documents are listed in table 6.

<table>
<thead>
<tr>
<th>Test</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bond Clamp Pullout Test</td>
<td>TR-NWT-000014, Section 4.4.1., and 5.4.1</td>
</tr>
<tr>
<td>Sealant (Encapsulant)</td>
<td>TR-NWT-000251, Section 4.3.8, and 5.3.8</td>
</tr>
<tr>
<td>Compression</td>
<td>PUB 55004, Section 4.72.A, and 5.42.A</td>
</tr>
<tr>
<td>Impact</td>
<td>PUB 55004, Section 4.72.B, and 5.42.B</td>
</tr>
<tr>
<td>Closure to Cable Integrity</td>
<td>PUB 55004, Section 4.72.C, and 5.42.C</td>
</tr>
<tr>
<td>Water Immersion Test</td>
<td>PUB 55004, Section 4.75.A, and 5.61</td>
</tr>
</tbody>
</table>

7.4 Optical fiber

7.4.1 General

Outdoor terminal hardware (e.g., environmental connecting hardware enclosures and splice cases) are used for storage and protection from direct exposure to moisture, corrosive elements or mechanical damage of optical fiber connections in an outdoor environment. Typical applications include underground installation, direct buried, above ground pedestals, and mounting directly on poles, strands or racks. Closures should accommodate various cable constructions and splice capacities for discrete and mass, mechanical and fusion optical fiber splices.

7.4.2 Optical fiber splice closure

7.4.2.1 General

An optical fiber splice closure, and the associated hardware, intended to restore the mechanical and environmental integrity of an optical fiber cable following a splicing operation. In addition, a splice closure provides the necessary facilities for organizing and storing optical fiber and splices. Optical fiber closures shall be able to be re-entered and watertight. See figure 17 for a typical optical fiber splice closure used in the OSP.

The expected operating environment for an optical fiber splice closure is between -40 °C and 70 °C (-40 °F and 158 °F). At these temperatures it is necessary that the closure not experience any functional degradation that could affect the performance of the closure. In addition there are several extreme environmental and mechanical conditions to which a closure may be subjected in certain deployment...
configurations. These include flood water or chemical exposure, sub-immersion in ice, and exposure to steam or fire.

Closures protect optical fiber splices from environmental hazards. Outdoor closures may be installed in pedestals, handholes, maintenance holes, and on poles and cable messenger strands. They shall be sized by calculating the number of splices, the amount and the density of the optical fiber and whether the cables are installed at one end or both ends of the splice closure. Optical fiber closures shall be capable of bonding and grounding cable shields and closures as required by applicable codes.

Figure 13 – Typical optical fiber splice closure used in OSP

7.4.2.2 Application

Splice closures are used to provide environmental protection for exposed cable cores (sheath removed) and exposed fibers. All have the capacity to house splice trays for protection of fibers. They are used to protect through splices (continuation of a run), branch splices or to splice "drop" fibers to nodes.

The following should be considered when selecting optical fiber splice closures:

a) Cable bend radii;

b) Fiber bend radii ≥ 38 mm (1.5 in);

c) Accommodate 4 cables;

d) Accommodate both inline and butt cable entry (inline cable entries are located at opposite ends of closure; butt cable entries are located at the same end of the closure);

e) Accommodate uncut feeder cable for tap/drop applications;

f) Have integral strand attachment hangers;

g) Accommodate offset hanging below existing coaxial cable;

h) Accommodate bonding/grounding (#6 AWG equivalent);

i) Must accommodate splicing trays to match closure capacity (splice trays are typically ordered separately); and

j) No special tools required.
7.4.2.3 Criteria

Optical fiber closures shall meet the following criteria:

a) Corrosion resistance of metal components. ASTM B 117 salt spray test for (30) days;

b) Chemical resistance of nonmetallic components (gasoline, kerosene, acid/base etc.);

c) Ultra-violet degradation of nonmetallic components. ASTM G 53 for (90 days - UVB-313 lamps) days;

d) Resistance to water/moisture ingress (as required by application);

e) Pressurization test: maintain 5 psi for 5 minutes and check for leakage (Sealed closures only);

f) Impact resistance (vandalism);

g) Effect of condensation (Temperature/humidity cycle);

h) Fungus resistance (ASTM 21); and

i) No light loss from cable clamping or cable movement.

7.4.2.3.1 Splice configurations

There are two principle cabling configurations for optical fiber splice closures, butt closures and in-line closures. Butt closures permit cables to enter the closure from one end only. This design may also be referred to as a dome closure. These closures can be used in a variety of applications including branch splicing. The second type of closure is an in-line configuration. In-line closures provide for the entry of cables at both ends of the closure. They can be used in a variety of applications including branch splicing and taut-sheath cable access. In-line closures can also be used in a butt configuration by restricting cable access to one end of the closure.

7.4.2.3.2 Common tests

Common tests for optical fiber closures are referenced in Telcordia document GR-771-CORE. See table 7.

<table>
<thead>
<tr>
<th>Test</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bond Clamp Retention</td>
<td>GR-771-CORE 5.2.1, 6.2.1</td>
</tr>
<tr>
<td>AC Fault Test</td>
<td>GR-771-CORE 5.2.2, 6.2.2</td>
</tr>
<tr>
<td>Cable Clamping</td>
<td>GR-771-CORE 5.3.1, 6.3.1</td>
</tr>
<tr>
<td>Sheath Retention</td>
<td>GR-771-CORE 5.3.2, 6.3.2</td>
</tr>
<tr>
<td>Cable Flexing</td>
<td>GR-771-CORE 5.3.3, 6.3.3</td>
</tr>
<tr>
<td>Cable Torsion</td>
<td>GR-771-CORE 5.3.4, 6.3.4</td>
</tr>
<tr>
<td>Vertical Drop</td>
<td>GR-771-CORE 5.3.5, 6.3.5</td>
</tr>
<tr>
<td>Central Member Protrusion</td>
<td>GR-771-CORE 5.3.8, 6.3.8</td>
</tr>
<tr>
<td>Thermal Aging</td>
<td>GR-771-CORE 5.4.1, 6.4.1</td>
</tr>
<tr>
<td>Assembly</td>
<td>GR-771-CORE 5.4.2, 6.4.2</td>
</tr>
<tr>
<td>Temperature and Humidity</td>
<td>GR-771-CORE 5.4.3, 6.4.3</td>
</tr>
<tr>
<td>Chemical Resistance</td>
<td>GR-771-CORE 5.4.8, 6.4.8</td>
</tr>
<tr>
<td>Fungus Resistance</td>
<td>GR-771-CORE 5.4.10, 6.4.10</td>
</tr>
</tbody>
</table>

7.4.2.3.3 Installation requirements

Optical fiber splice closures shall be accessible for maintenance personnel and maintenance vehicles. A location for the closure should be chosen that is away from high traffic or conditions that could cause damage to the closure or injury to personnel.

When using armored cable, the armor shall be bonded and grounded per applicable code. This is accomplished with the use of a bonding connector that is attached to the armor of the cables. A bonding
wire is connected between all of the cables in the closure. Grounding wires are run from the connectors to the attachment on the closure. The closure is then grounded to a grounding bar or wire.

### 7.4.2.4 Free-breathing optical fiber closures

Free-breathing closures provide all of the features and functions expected of a typical splice closure in an enclosure that prevents the intrusion of wind-driven rain, dust and insects. Such a closure, however, permits the free exchange of air with the outside environment. Therefore, it is possible that condensation will form inside the closure. Thus, it is necessary to provide adequate drainage to prevent the accumulation of water inside the closure. Deployment of free-breathing closures in OSP should be restricted to aerial and ground-level applications where there is no risk of water immersion or exposure to chemicals.

#### 7.4.2.4.1 Special testing

Special tests for free-breathing optical fiber splice closures are described in Telcordia document GR-771-CORE. See table 8.

<table>
<thead>
<tr>
<th>Test</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression at 45 kg (100 lb)</td>
<td>GR-771-CORE 5.3.6, 6.3.6</td>
</tr>
<tr>
<td>Impact at 68 N-m (50 ft-lb)</td>
<td>GR-771-CORE 5.3.7, 6.3.7</td>
</tr>
<tr>
<td>Weather-tightness</td>
<td>GR-771-CORE 5.4.5., 6.4.5</td>
</tr>
<tr>
<td>Water Resistance: Wind-driven rain</td>
<td>GR-771-CORE 5.4.6, 6.4.6</td>
</tr>
<tr>
<td>Corrosion Resistance: Salt fog</td>
<td>GR-771-CORE 5.4.7, 6.4.7</td>
</tr>
<tr>
<td>Ultraviolet Resistance</td>
<td>GR-771-CORE 5.4.9, 6.4.9</td>
</tr>
<tr>
<td>Rodent Resistance</td>
<td>GR-771-CORE 5.5.3, 6.5.3</td>
</tr>
</tbody>
</table>

#### 7.4.2.4.2 Sealed aerial closures

The sealed aerial closures are commonly the same closures used for underground applications with the addition of aerial hanger hardware. The sealed aerial closures shall be designed to provide an air tight protective enclosure for the storage of fiber and fiber splices.

#### 7.4.2.4.3 Vented aerial closures

Vented aerial closures are designed to provide a weather tight protective enclosure for the storage of optical fiber and fiber splices. Air vents are provided to permit the free exchange of atmospheric air and to allow the drainage of any moisture or condensation.

#### 7.4.2.5 Underground closures

Underground closures are designed to provide air tight/water tight protection for fiber and fiber splices. Sealing is accomplished with mastic materials, gaskets or heat reactive materials. These closures shall be used in applications where temporary or permanent water submergence may occur. This includes below ground vaults, maintenance holes, handholes and pedestals located in low ground locations.

#### 7.4.2.6 Direct-buried closures

Direct-buried closures are designed to provide a water tight protective enclosure for the storage of fiber and fiber splices. These closures typically achieve splice protection by means of a nonmetallic closure body and a curable encapsulate to allow re-entry. Provisions are made to keep the encapsulant away from direct contact with the fiber.

Hermetically sealed closures (HSCs) provide all of the features and functions expected of a typical splice closure in an enclosure that prevents the intrusion of liquid and vapor into the closure interior. This is accomplished through the use of an environmental sealing system such as rubber gaskets mastics or hot-melt adhesives. Following installation, an HSC can be pressurized in the field to check the integrity of the environmental seal. HSCs represent the most robust environmental protection available for optical fiber
splice closures. HSCs are generally required for deployment in the buried or underground plant and in any other deployment scenario where exposure to chemicals or corrosive agents is expected.

HSCs shall be equipped with a fitting capable of accommodating an air valve to permit pressurization of the closure for the purpose of verifying the integrity of the closure seal.

7.4.2.6.1 Special tests

Special tests for direct-buried optical fiber splice closures are described in Telcordia document GR-771-CORE. See table 9.

Table 9 – References for direct-buried optical fiber splice closures test methods

<table>
<thead>
<tr>
<th>Test</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression at 135 kg (300 lb)</td>
<td>GR-771-CORE 5.3.6, 6.3.6</td>
</tr>
<tr>
<td>Impact at 440 N(100 ft-lb)</td>
<td>GR-771-CORE 5.3.7, 6.3.7</td>
</tr>
<tr>
<td>Freeze/Thaw</td>
<td>GR-771-CORE 5.4.4, 6.4.4</td>
</tr>
<tr>
<td>Water Resistance; 6.1 m (20 ft) water head</td>
<td>GR-771-CORE 5.4.6, 6.4.6</td>
</tr>
<tr>
<td>Corrosion Resistance: Acidified saltwater</td>
<td>GR-771-CORE 5.4.7, 6.4.7</td>
</tr>
</tbody>
</table>

7.4.2.7 Shield isolation/grounding closure

Shield isolation/grounding closures are designed to provide an air tight/water tight protective enclosure for an optical fiber cable sheath opening. The closures function not as splice locations but only as access points for shield isolation and/or shield grounding.

7.4.2.8 Pedestal optical fiber closure

Pedestal optical fiber closures contain a splice closure that is located inside a ground-level pedestal. It’s primary mechanical strength comes from a pedestal. The pedestal is flood resistant and resistant to wind driven rain, in which case the splice closure may be free-breathing.

7.4.2.8.1 Special tests

Special tests for pedestal optical fiber splice closures are described in Telcordia document GR-771-CORE. See table 10.

Table 10 – References for pedestal optical fiber closure test methods

<table>
<thead>
<tr>
<th>Test</th>
<th>Test method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression at 45 kg (100 lb)</td>
<td>GR-771-CORE 5.3.6, 6.3.6</td>
</tr>
<tr>
<td>Weather-tightness</td>
<td>GR-771-CORE 5.4.5, 6.4.5</td>
</tr>
<tr>
<td>Water Resistance: 3 m (10 ft) water head</td>
<td>GR-771-CORE 5.4.6, 6.4.6</td>
</tr>
<tr>
<td>Corrosion Resistance: salt fog</td>
<td>GR-771-CORE 5.4.7, 6.4.7</td>
</tr>
<tr>
<td>Ultraviolet Resistance</td>
<td>GR-771-CORE 5.4.9, 6.4.9</td>
</tr>
</tbody>
</table>
ANNEX A (NORMATIVE) OSP SYMBOLS

This annex is normative and is considered part of this Standard.

A.1 General

The following symbols shall be used in the design of customer-owned OSP. Documentation shall be accompanied by a legend specifying all symbols used.

- Existing cable
- Proposed cable
- Future cable
- To be removed
- Buried cable
- Buried in joint trench (C=CATV, E=Electric, G=Gas)
- Underground duct or cable in duct
- Gauge, type and size
- Submarine Cable
- Change in cable size, gauge, count or type
- Point on cable (other than splice), where a division of measurement or point of record is required
- Existing straight splice
- Proposed straight splice
- Encapsulated splice
- Cable loop – no splice involved
- Pairs cut and ends cleared in splice enclosure
- Cable cut, ends cleared and capped
- Insulating joint
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1702</td>
<td>Fixed-count terminal</td>
</tr>
<tr>
<td>1703</td>
<td>Fixed-count terminal with cable protection</td>
</tr>
<tr>
<td>1704</td>
<td>Interface with moisture plug</td>
</tr>
<tr>
<td>1705</td>
<td>Case with factory equipped stub</td>
</tr>
<tr>
<td>1706</td>
<td>Load coils and case</td>
</tr>
<tr>
<td>1707</td>
<td>Repeater station – two way</td>
</tr>
<tr>
<td>1708</td>
<td>Capacitor (wire diagram)</td>
</tr>
<tr>
<td>1709</td>
<td>Optical fiber cable</td>
</tr>
<tr>
<td>1710</td>
<td>Multiplexer</td>
</tr>
<tr>
<td>1711</td>
<td>Fixed count terminal block spliced to cable</td>
</tr>
<tr>
<td>1712</td>
<td>Ready access type connecting block; pairs terminated on a fixed count basis</td>
</tr>
<tr>
<td>1714</td>
<td>Protected fixed count type terminal block spliced</td>
</tr>
<tr>
<td>1715</td>
<td>Protected block spliced to cables with pairs terminated on a ready access type connecting block</td>
</tr>
<tr>
<td>1717</td>
<td>Optical fiber cable termination</td>
</tr>
</tbody>
</table>
1718  
CMDW-6 PR  
One 6-pair Multiple Drop Wire

1719  
B  
S – B5 PR  
Buried wire

1720  
Non-protected wire terminal

1721  
Protected wire terminal

1722  
Ground

1723  
Ground to multiground neutral vertical

1724  
Power multigrounded neutral

1725  
Telecommunications ground rod

1726  
Power neutral bond

1727  
Bond between separate cable strands

1728  
Existing pole
1729

Proposed Pole

1730

Pole to be removed

1731

Non-wood pole

1732

Anchor only

1733

Guy only

1734

Anchor and guy

1735

Anchor and insulated guy

1736

Sidewalk anchor and guy

1737

Push Brace

1738

Anchor and guy owned by others

1739

Underground conduit, manhole and subsidiary conduit to pole

1740

1741

Proposed maintenance hole – type, length, width, headroom and type of frame and cover

1742

1743

Trench meters of conduit and type of duct

1744

Placing stamp
Splice and splice number

Transferred pairs in splice
This annex is normative and is considered part of this Standard.

### B.1 General

As fiber optic cables have become increasingly common in communications construction, much publicity has been given to instances of cable cuts resulting in loss of service, and to fixing of responsibility. Much publicity has also been given to the fact that physically small fiber optic cables can carry enormously greater numbers of communication circuits than do copper conductor cables of comparable size.

The contracting industry has been alarmed by the difficulty of determining and verifying the presence and location of fiber optic facilities and the total impact of cable cuts. The communications facility operators are also concerned about the number of cuts that have been occurring, and they want to reduce service interruptions.

This annex specifies the depth at which below-ground cables must be placed and separated from other underground facilities. It covers other protective measures that should be observed to reduce the probability of damage resulting from work operations in the vicinity of such cables. The annex also recommends responsibilities and procedures for damage-prevention activities on the part of excavators and facility owners.

The annex addresses cables that are directly buried, placed in duct, in non navigable waterways, or in transition from underground to aerial structures. It further specifies the location-marking and physical and operational protection of such cables.

This annex does not address installation methods or existing cable plant, nor does it cover aerial, building, and submarine cables, or cables placed in navigable waterways.

### B.2 Requirements

Component requirements for duplex and array connector systems, as described in this clause, are specified in ANSI/TIA-568-C.3.

#### B.2.1 Cable installation planning

The facility owner is responsible for correct route design and installation of the cable. Cable plant should be constructed in accordance with plans and specifications prepared under the supervision of a qualified engineer. The proper design of a cable below-ground route is important, this being the first step in avoiding damage to that cable by future work operations performed in the area.

The following guidelines are provided to convey additional advice and information and to emphasize that cable placement should be in accordance with this Annex and recognized industry installation procedures. They should not be taken as all-inclusive and may not be applicable to all installations.

- Plans for the location and installation of below-ground cable should be made using information obtained from a field survey.
- The installation plans should identify the fiber cable facility's route, placing and depth information, and information sufficient to locate other subsurface structures. Special measures to be taken for known conflicts and obstructions should be provided, and nearby structures that can assist as landmarks for route identification and future facility location should be shown and noted.
- In recognition of possible right of way congestion, the route design should take into account interference between the present installation and future subsurface structures.
- Once the route is planned, right of way and required permits should be obtained, recognizing needs for access, work area, equipment enclosures, and future maintenance. Land acquisition rights and permission should be obtained before installation work begins.
When appropriate for the project, the facility owner should conduct a preconstruction meeting with involved local government agencies, contractors and other utilities to cover construction plans, schedules, sequence of operations, and other concerns.

The facility owner should conduct inspections as necessary to ensure that the installation is in accordance with the approved plans.

As built facility location records should be maintained by the facility owner. Location record information should be available for reference when other parties or government agencies are planning work in the area to allow them to plan to avoid damage or conflicts with the cable facilities. As built records cannot be expected to reflect subsequent changes in landscape, public works, landmarks, or foreign underground structures. Such records cannot be considered as a substitute for field locating and marking of the fiber cable as required in B.2.10.4.

B.2.2 Location

B.2.2.1 Depth of plant

Buried or conduit plant as described in table 11 shall be installed so that a minimum depth of cover as shown in the table is obtained. In conditions where this depth is not feasible or permitted, additional physical protection should be afforded the facility. Deviations from these requirements may lead to additional risks and must be evaluated on an individual case basis.

### Table 11 - Depth of plant

<table>
<thead>
<tr>
<th>Facility</th>
<th>Minimum cover mm (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toll, trunk cable</td>
<td>750 (30)</td>
</tr>
<tr>
<td>Feeder, distribution cable</td>
<td>600 (24)</td>
</tr>
<tr>
<td>Service/drop lines</td>
<td>450 (18)</td>
</tr>
<tr>
<td>Underground conduit (see NOTE)</td>
<td>750 (30)</td>
</tr>
</tbody>
</table>

NOTE – Main conduit runs (or routes), with maintenance hole access. For other duct applications, depth requirements for buried plant shall apply.

B.2.2.2 Joint construction

Depth of cover for power cables is governed by National Electrical Safety Code (NESC) Rule 353D. For joint facilities, the minimum depth of cover shall be determined either from table 11 above, or table 12, whichever depth is greater.

### Table 12 - Depth of electrical supply cable

<table>
<thead>
<tr>
<th>Maximum Voltage Phase-to-Phase, Volts</th>
<th>Depth of Cover, mm (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 600</td>
<td>600 (24)</td>
</tr>
<tr>
<td>601 to 50,000</td>
<td>750 (30)</td>
</tr>
<tr>
<td>50,001 and above</td>
<td>1070 (42)</td>
</tr>
</tbody>
</table>

Additional requirements for random separation of power cables and communications cables at the same depth with no deliberate separation between them are covered in NESC Rule 354C. Where conduit is required for short special conditions in buried distribution systems, separate ducts for power and communications facilities must be provided as covered in NESC Rule 341A6.

B.2.2.3 Separations from foreign structures

The minimum desirable separation between existing foreign structures and communications cables (or underground conduit containing communications cables) should be as shown in table 13.
<table>
<thead>
<tr>
<th>Electric-light, power, or other conduits</th>
<th>Other foreign services: gas, water, oil, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 mm (3 in.) of concrete</td>
<td>300 mm (12 in.) from transmission pipelines</td>
</tr>
<tr>
<td>100 mm (4 in.) of masonry</td>
<td>150 mm (6 in.) from local distribution pipelines</td>
</tr>
<tr>
<td>300 mm (12 in.) of earth</td>
<td>(Unless greater separations are required by state or local regulations)</td>
</tr>
</tbody>
</table>

These clearances are necessary to provide sufficient space for maintenance of foreign structures, although they may be subject to adjustment to meet particular conditions. Questions that occur regarding any reduction of these clearances should be discussed with a responsible representative of the owning company.

### B.2.2.4 Permanent markings

Either permanent above-ground markers or underground warning tape, or both, are recommended to identify the general location of the facility route. These devices, however, cannot be relied upon to determine the precise location of the underground facility.

Permanent markers should be placed at line-of-sight intervals so that the direction of the route is clearly indicated. These markers should be visible from the adjoining marker, but separated by no more than 300 m (1000 ft.), if land use permits. Markers are usually placed at right-of-way boundaries, utility or vehicular crossings, or at other locations dictated by local conditions. These markers should be identified with the name of the facility owner and one or more telephone contact numbers to obtain the precise facility location.

Where a warning tape is used, it should be buried at least 300 mm (12 in.) above the cable and should not deviate more than 450 mm (18 in.) from the outside edge of the facility. Care must be exercised during its placing to ensure proper final positioning of the tape. The use of warning tape above service or drop lines on private property is optional.

Warning tapes should have sufficient tensile strength and elongation properties so that when encountered in excavating they are not easily broken and will stretch significantly before breaking. Extended periods of burial in soil should not degrade their mechanical characteristics, color, or markings. Tapes with metallic coatings will generally exhibit less elongation than dielectric tapes. Tapes should be at least 50 mm (2 in.) wide and colored orange in accordance with the Uniform Color Code of the American Public Works Association (APWA) – Utility Location and Coordination Council (ULCC). The tape should be marked with warning information identifying the type of facility that is below. Additional information is desirable to show specific contact information and to identify the facility owner. No quantitative performance characteristics for tape can be stated, since no industry annex specification for warning tape is known to exist. Warning tape, when used, should not be relied upon as a primary locating device for the cable.

### B.2.2.4.1 Uniform Color Code

An APWA guide that has been accepted as a national convention for the color-coded temporary marking of subsurface facilities to prevent accidental damage by those excavating nearby. The Uniform Color Code was developed by the Utility Location and Coordination Council (ULCC) and adopted by the APWA to both mark and identify subsurface facilities. This color code is also recommended for permanent above-ground and below-ground markings. The colors assigned and types of facility are specified in table 14.
Table 14 - Uniform color code

<table>
<thead>
<tr>
<th>Color</th>
<th>Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Electric power lines and conduit</td>
</tr>
<tr>
<td>Yellow</td>
<td>Gas, oil, steam, and petroleum lines</td>
</tr>
<tr>
<td>Blue</td>
<td>Water, irrigation, and slurry lines</td>
</tr>
<tr>
<td>Green</td>
<td>Sewer and drain lines</td>
</tr>
<tr>
<td>Orange</td>
<td>Communication lines, including fiber optic cable</td>
</tr>
<tr>
<td>White</td>
<td>Proposed excavation</td>
</tr>
<tr>
<td>Pink</td>
<td>Temporary survey markings</td>
</tr>
</tbody>
</table>

B.2.3 Riser poles

Cables on riser poles should have mechanical protection such as a duct or U guard on the pole extending from the ground for approximately 2.5 meters (8 feet). This mechanical protection should extend below ground level via a conduit bend to the specified burial depth of the cable (see table 12). Risers should be located on the pole in the safest position with respect to possible traffic damage and climbing space. For added cable protection above the U guard or duct, the fiber cable may be placed in innerduct extending above the U guard up and onto the supporting aerial strand. From an underground conduit, this innerduct may be run from the maintenance hole, through the subsidiary duct and U guard onto the supporting aerial strand.

B.2.4 Building entrances

Buried fiber cable may enter a building at the same depth as the facility (see table 12) through the building wall via a duct. Entrance to a building may also be made above ground. The exposed fiber cable should be secured to the building and mechanically protected with conduit, innerduct, or U guard.

B.2.5 Underwater cable crossings

The Army Corps of Engineers regulates activities involving interstate waters and associated marshes and tributaries; intrastate waters, which could affect interstate or foreign commerce; and the territorial seas for a seaward distance of 5 km (3 mi.). The Corps is responsible for work up to the headwaters of freshwater streams, wetlands, swamps, and lakes.

The Corps’ Regional District Engineer will advise applicants as to the types of permits required for proposed work. Any of the Corps’ District Engineers, located in many major cities of the country, will advise and inform applicants of the requirements to obtain permits for activities in waters under their jurisdiction. A pamphlet titled Regulatory Program — Applicant Information is available and provides permit information. The address for the Headquarters of U.S. Army Corps of Engineers is:

Headquarters, U.S. Army Corps of Engineers - CECW-OR
20 Massachusetts Ave., N.W.
Washington, D.C. 20314-1000
202-761-0660

In addition, even where a Corps permit is required, an environmental review and permit from a state or local agency, or both, may also be required. The state and local agencies should be contacted to ensure compliance with environmental review statutes and regulations. Permission or easements from property owners may also be required.

B.2.6 Railroad crossings

A railroad must be notified of a planned cable crossing their railroad tracks or property. The facility owner is responsible for the engineering and construction of the railroad crossing, including preparing a subsurface profile of the construction site. The chief engineer of the railroad should be consulted to determine the approved methods of crossing the railroad.

For assistance in preparing the design details and plans of underground crossings and railroad bridge crossings, which must be approved by the railroad, reference may be made to Recommended Practices...
for Communication Lines Crossing the Tracks of Railroads, Part 1 B 1, of the Association of American Railroads. The Association's address is:

Association of American Railroads
425 Third Street
SW Suite 1000
Washington, DC 20024
Tel. (202) 639 2100
www.aar.org

Where additional details for the encasing of conduit are needed, contact the American Railway Engineering Association (AREMA) at the above address, telephone (202) 639 2100. The AREMA Manual for Railroad Engineering, chapter 1, part 5, covers steel pipe encasement specifications.

Work must be done at a time when it will not interfere with proper and safe use or operation of the property and tracks of the railroad company. Arrangements have to be made with the duly authorized representative of the railroad company for the date and time to begin work.

**B.2.7 Bridge crossings**

The diversity of bridge designs and structures makes it impractical to prescribe installation standards for cable bridge crossings. Conduit is normally used to provide the structure and mechanical protection for these cable crossings.

Each bridge crossing must be individually designed to conform to local conditions and constraints imposed at the bridge site. The design of the conduit assembly and associated support structure, or cable attachment, should be consistent with pertinent local regulations controlling bridge construction. Where no guidelines exist for structural design, reference should be made to Annex Specifications for Highway Bridges, published by the American Association of State Highway and Transportation Officials (AASHTO).

The American Association of State Highway and Transportation Officials (AASHTO) address is:

AASHTO
444 N. Capital St., NW
Suite 225
Washington, D.C. 20001
Tel. (202) 624 5800

The design of bridge cable crossings must be compatible with the cable approach, must ensure that the cable is not subject to damage by normal bridge use, and must maintain the required clearances over railroads or other traveled ways crossed. Separation of the fiber cable from other utilities on the bridge should be in accordance with the provisions of the National Electrical Safety Code or other appropriate regulations.

Attachment should not be made to the bridge until approval is secured from the proper authority.

**B.2.8 Tunnel installations**

Each tunnel will have its own unique environmental and administrative requirements. To ensure continued use of the tunnel for a cable facility, written permission and agreement should be obtained from the tunnel regulatory authority, or owner(s). Such permit agreements should cover installation methods as well as administrative and operating rules for this occupancy and accommodation. Each situation must be evaluated in accordance with the tunnel's basic use, environment, and presence of other utilities to minimize the possibility of damage to the cable.

Installation standards for tunnels cannot be limited to mechanical and structural aspects alone. In the National Electrical Safety Code, Section 39, requirements are listed for environmental factors that should be observed and other applicable requirements contained in Part 3 of the Code. Also, suitable corrosion resistant markers or cable tags showing appropriate facility owner operator information should be placed to facilitate visual identification of the fiber cable.
B.2.9 Highway accommodations

All states, and many political subdivisions, have statutes or regulations that permit and define the use and occupancy of public highways and streets. Franchise agreements may also specify the legal rights covering the placement of utility facilities in highway right of way.

A basic reference for highway utility use is A Guide for Accommodating Utilities Within Highway Right of Way, issued by the American Association of State Highway and Transportation Officials (AASHTO). It may be referred to and used to the extent that it is consistent with state and local laws and policies for accommodating utility facilities in highway right of way.

The guidelines for placement of cables in highway rights of way are to be interpreted to the extent that they are consistent under the responsible highway authority's rules, codes, and regulations.

Highway design and type, soil conditions, traffic levels and patterns, and zoned land use restrictions will affect the ultimate cable installation accommodations along specific highway rights of way.

For interstate highway right of way (IHROW) accommodation, the Federal Highway Administration (FHWA) authorizes state highway agencies to approve individual requests for the installation of designated facilities in the IHROW. Each state's policies and procedures for authorization of IHROW utility accommodation must be approved by the FHWA. A state has the latitude to permit, or not permit, certain classes of facility in the IHROW.

B.2.10 Excavating responsibilities and procedures

B.2.10.1 Damage prevention laws

Most states have damage prevention laws that address the responsibilities of excavators and facility owners. These laws are intended to ensure safe work operations and reduce the possibility of damage to existing subsurface facilities.

B.2.10.1.1 Regulations

The state damage prevention laws now vary as to facilities or services covered, time for advanced notification to facility owners before actual excavation starts, size of tolerance zone, specifying use of the Utility Location and Coordination Council (ULCC) uniform color code for temporary facility location marking, facility owner registration at a local government office and/or required participation in a one call bureau, and specifying a penalty clause for not following the regulations. Reference should be made to the specific state law in effect. In addition, the Federal Occupational Safety and Health Administration (OSHA) under the Code of Federal Regulations, title 29, chapter XVII in subpart P, Excavations, section 1926.651, states that "The estimated location of utility installations, such as sewer, telephone, fuel, electric, water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, shall be determined prior to opening an excavation." The regulation also states that utilities shall be advised of proposed work before the start of an actual excavation. No details or procedures are specified for doing these functions required under OSHA regulations for prevention of accidental underground facility damage.

Local government regulations may require compliance with local procedures in addition to state regulations. For example, some cities require an excavator to show the one call bureau's serial number, received by the excavator when the call is made to the bureau, in order to obtain any associated highway permit.

Facility owners and excavators should be knowledgeable about the specific laws and regulations governing damage prevention methods and procedures for their operating areas. If both parties follow not only the letter but the intent of such laws, it will minimize accidental damage to subsurface cable facilities and thereby reduce liability exposure of the excavators, and service interruptions.

B.2.10.2 "Call before you dig" responsibilities

Both parties, excavators and facility owners, bear responsibility for the successful operation of the "call before you dig" damage prevention program. This requires that each underground facility owner should belong to the one call bureau(s) that cover their operating area(s), and that each excavator should contact the one call bureau before excavation begins.
B.2.10.1.3 One Call Bureau

An organization established by two or more agencies or companies to provide one telephone number for excavators, utilities, public agencies, and private citizens to call to notify facility owners of their intent to excavate. Calling the one call bureau is intended to be the means of notifying all participating facility owners to locate and mark their facilities in the vicinity of the proposed work to prevent facility damage by the excavator.

A one call bureau may serve an entire state. Some states have several one call bureaus covering specific areas. The Common Ground Alliance (CGA) publishes an annual directory that gives the names, addresses, and telephone numbers of all one call bureaus. A copy of this directory may be obtained by contacting:

- Common Ground Alliance
  1421 Prince Street
  Alexandria, VA 22314
  Telephone: 703-836-1709
  Facsimile: 309-407--2244

Excavators and owners may also obtain further information concerning programs and publications from the CGA headquarters.

B.2.10.2 Other information sources

Listed below are various information sources available to an excavator, in addition to one call bureaus, to determine the facility owners to be notified before excavation begins at a site.

B.2.10.2.1 Central Registries

Where state laws or local regulations do not require facility owners to join a one call bureau, or in the few areas not served by a one call bureau, the excavator must check central registries (county or township record centers) to identify all facility owners and notify them before excavation work is started. State damage prevention laws generally cover central registration.

B.2.10.2.2 Other records and references

In states where there is no damage prevention statute, other government records and references must be used to identify facility owners so that they can be notified before excavation work begins. Utility operating franchise areas may be obtained from the state regulatory commission, state corporation commission, or attorney general's office, or directly from the utility. Local political subdivision tax records and public works department plat records may be referred to for other classes of facility owners, such as private corporations, government networks, etc.

B.2.10.3 Recommended procedures for excavators

To avoid accidental damage to existing subsurface cables as well as to other facilities, it is recommended that excavators follow these procedures. All of the following steps may or may not be specified in a state's damage prevention law, but it is recommended that they be followed by the excavator to decrease the likelihood of damage to facilities.

B.2.10.3.1 Notification of facility owners

The excavator should notify all possibly affected facility owners of details of the excavation site start date; the work to be performed; and the excavator's name, address, and telephone number. The use of the one number call bureau is the preferred method for the possibly affected facility owners to receive notices. Where a one call bureau does not exist, other sources to determine facility owners to notify are needed (see B.2.10.2.2). Such notification should be done within the required number of working days, per the state damage prevention law, before the start of excavation site work. If there is no specified excavator notification lead time, a minimum of two, or a maximum of ten working days notice should be provided before the excavation site start date. Under emergency or hazardous conditions, the excavator may proceed without prior facility owner(s) notification, using extreme caution to prevent facility damage, and should notify them as soon as possible.
Excavation marking

Where feasible, the excavator should mark or indicate the area or direction of the proposed excavation, using a color that will not conflict with the ULCC’s uniform color code. White is recommended. This will guide the facility owner(s) to locate and mark their facility at the proper excavation location. The facility markings should also indicate the name, initials, or logo of the excavator.

Commencement of work

The excavator may proceed with the excavation on the stated start date only after all existing facility locations have been marked, or the excavator has been notified by the owners that no facility is located at the excavation site, or if a facility owner has not responded within the time allowed.

Protection of marking

The temporary facility marking or staking (or both) placed by the owner to locate the facility should be protected and preserved by the excavator after excavating begins, until these markings are no longer required for safe excavation near the below-ground facility. Where such markings cannot be reasonably maintained due to circumstances beyond the excavator’s control, the facility owner should be contacted for assistance or re-marking.

Use of nondestructive excavation methods

The excavator should use hand or nondestructive tools within the tolerance or safety zone to expose the facility. The width of this zone, if not specified by the state damage prevention law, should be 450 mm (18 in.) from the edges of the facility per the owner’s marking (see figures 1 and 2). If the facility cannot be located within the tolerance zone, the owner should be notified.

Backfilling

The excavator, when backfilling, should avoid damage to the facility from equipment, rocks, rubble, other heavy or sharp objects, heavy loads, or excessive force.

Damaged facilities

The excavator should immediately report discovery of a damaged facility, or if it is otherwise at risk of failure, to the owner.

Unknown or unmarked facilities

The excavator should report discovery of an unknown or unmarked facility. If the owner cannot be determined, notify the one call bureau or the facility owners listed on a central registry list.

Codes and regulations

Excavators should comply with all other applicable OSHA, state, and local codes and regulations, and accepted industry practices.

Recommended procedures for facility owners

The following are the facility owners’ responsibilities that are recommended to minimize the likelihood of accidental damage to subsurface fiber cable facilities. Even though the following steps may not be specified in damage prevention laws and regulations, it is recommended that they be followed by the facility owner to decrease the likelihood of damage to facilities.

Central registries

The facility owner, when required by state law or regulations, should register with the central registry of the city, town, or county. In addition, whether or not required by law to register, each facility owner should become a member of the one call bureau(s) covering the area(s) of the owner’s operation.
B.2.10.4.2 Marking of facilities

When notification of excavation is made as stated in B.2.10.3.1, owners should complete marking of the facility location within two working days of notification, or by a mutually agreed-upon date. If not otherwise specified by state law or other regulations, all facilities within 3 meters (10 feet) of the excavation site should be located and marked. The owner should notify the excavator when no facility will be affected by the excavation.

B.2.10.4.3 Marking of owners facilities

Facility owners should clearly ground-mark their facility's location and route if the facility is within 3 meters (10 feet) of the excavation site. The ULCC Uniform Color Code temporary marking color should be used to mark the centerline of the facility. Markings should include the name, initials, or logo of the owner, and the width of the facility where that width is greater than 50 mm (2 in.). (Orange is the ULCC-specified marking color for all communication facilities, which includes fiber optic cable.) The facility location markings should be made above and in line with the facility, not placed at an angle over the facility, to allow for correct determination of the tolerance zone. Stakes, where used to supplement surface markings, should be clearly identified with the ULCC Uniform Color Code orange on at least the top 150 mm (6 in.) of the stake. (See figures 14 and 15). The owner should notify the excavator when marking is complete.

B.2.10.4.4 Marking exceptions

The owner should notify the excavator if the facility cannot be marked before the excavation start date. The owner should arrange with the excavator for a prompt new marking completion date or schedule, as may be specified by state law. If requested by the excavator, the owner may assign an on site representative to provide facility locating services until normal facility marking has been completed.

B.2.10.4.5 Offset staking and marking

Where conditions exist that will not allow centerline facility marking, offset staking and marking should be used. This marking will clearly indicate distance and direction of the facility from the offset stakes.

B.2.10.4.6 Special situations

Where marking or staking cannot be used or is insufficient, the operator should designate the facility location during an on site meeting with the excavator. The facility should be exposed sufficiently to verify its location and direction, or its location should be determined by other means that are mutually agreeable.

B.2.10.4.7 Call for assistance

The facility owner should respond promptly to an excavator's call for assistance in facility locating, review of markings, identification of an unknown facility, damage, or other emergency request.

B.2.10.4.8 Marking materials

Selection of the materials and methods used to apply the ULCC Uniform Color Code temporary markings should be such that the markings will remain in place until no longer required by the excavator. The facility owner should respond promptly when notified by the excavator that a facility's markings have not been preserved.

B.2.11 Damage restoration

Facility owners should be prepared to restore cable damage. The way to meet a service emergency is to prepare in advance for handling it. Each damage case presents different situations, circumstances, and conditions that should be handled and coordinated for rapid service restoration.

No listing can be expected to cover the specific handling of all types of damage cases. The owner should establish overall procedures and routines with appropriate practices for each operation essential to the restoration work.
The generic items and procedures for restoration work include:

- Spare-cable requirements for restoration and repair work — lengths, type, quality, inventory, and availability, based on network layouts and design
- Network records, maps, installed-facility measurement data, requirements, and availability needed for rapid and effective restoration of service
- Splicing restoration kits — tools, materials, test-set availability and inventory
- Trained facility personnel
- Restoration site procedures based on temporary or permanent restoration requirements:
  a) for temporary restoration, protect the site until permanent restoration is made
  b) make facility test measurements of both temporary and permanent restoration
  c) request assistance of excavator if required.
- Complete reports and documentation.

**Figure 14** – Fiber cable marking and tolerance zone, facility less than 50 mm (2 in.) wide
FIBER CABLE MARKING AND TOLERANCE ZONE
NAME, INITIALS OR LOGO, FACILITY OWNER/OPERATOR
For Facility Over 50 mm (2 in) Wide

FLAG or STAKE
FACILITY WIDTH

TOLERANCE ZONE
450 mm + 600 mm + 450 mm = 1.5 m

FIBER CABLE IN DUCT BANK

600 mm (24 in)

Fiber cable marking and tolerance zone, facility over 50 mm (2 in.) wide

As-built facility location record

This record contains physical location information and details needed to assist in locating the fiber optic cable. Details should also include the location of abrupt deviations taken from the cable’s normal planned route and placing depth. Such deviations, caused by foreign underground structures or geological obstructions, whether planned in advance or uncovered during the cable installation should be recorded when:

- horizontal deviations made from the facility’s route extend beyond the tolerance zone specified in the applicable damage prevention law or, where none is specified, by an equivalent 450-mm (18-in.) tolerance zone from either side of the facility (see figures 18 and 19).
- any vertical deviation that results in a depth less than the design minimum, or a depth exceeding the design minimum by 300 mm (12 in.) or more.

The measurements giving the location and extent of such deviations should be noted either when the route is planned, or reported at the time the obstruction is discovered during installation of the facility.
This annex is informative only and is not part of the Standard.

This annex contains information on the documents that are related to this document. Many of the documents are in print and are distributed and maintained by national or international standards organizations. These documents can be obtained through contact with the associated standards body or designated representatives. The applicable electrical code in the United States is the National Electrical Code.

- ANSI/TIA-455, Test Procedures for Fiber Optic Fibers, Cables and Transistors
- ANSI/TIA-472CAAA, Detail Specification for All Dielectric (Construction 1) Fiber Optic Communications Cable for Indoor Plenum Use, Containing Class Ia, 62.5 mm Core Diameter/125 mm Cladding Diameter Optical Fiber(s)
- ANSI/TIA-472DAAA, Detail Specification for All Dielectric Fiber Optic Communications Cable for Outside Plant Use Containing Class Ia, 62.5 mm Core Diameter/125 mm Cladding Diameter/250 mm Coating Diameter Optical Fiber(s)
- ANSI/TIA-492AAAA, Detail Specification for 62.5 m Core Diameter/125 m Cladding Diameter Class Ia Multimode, Graded-Index Optical Waveguide Fibers
- ANSI/TIA-492BAAA, Detail Specification for Class IVa Dispersion-Unshifted Single-mode Optical Waveguide Fibers Used in Communication Systems
- ANSI/TIA-526-7, Optical Power Loss Measurements of Installed Single-mode Fiber Cable Plant
- ANSI/TIA-526-14, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant
- ANSI/TIA-598, Color Coding of Optical Fiber Cables
- ANSI/TIA-604-3, FOCIS 3 Fiber Optic Connector Intermateability Standard
- ANSI/TIA-604-2, Focus to FOCIS, Fiber Optic Connector Intermateability Standard
- ANSI/IEEE C 62.11, Metal Oxide Surge Arrestors for AC Power Circuits
- ANSI X3.166-1990, ANSI Standard for Token Ring FDDI Physical Layer Medium Dependent (PMD)
- ASTM B539-90, Measuring Contact Resistance of Electrical Connections (Static Contacts)
- EIA-492A000, Sectional Specification for Class Ia Multimode, Graded-Index Optical Waveguide Fibers
- FOTP-203 (TIA-455-203), Launched Power Distribution Measurement Procedure for Graded Index Multimode Fiber Transmitters
- FOTP-204 (TIA-455-204), Measurement of Bandwidth on Multimode Fiber
- IEEE 802.3-1990 (also known as ANSI/IEEE Std 802.3-1990 or ISO 8802-3: 1990 (E), Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications
- IEEE 802.4, Standard for Local Area Network Token Passing Bus Access Method, Physical Layer Specification
- IEEE 802.5-1992 (also known as ANSI/IEEE Std 802.5-1992), Token Ring Access Method and Physical Layer Specifications
- IEEE 802.7, (also known as) Recommended Practices for Broadband Local Area Networks
- NEMA-250-1985, Enclosures for Electrical Equipment (1000 Volts Maximum)
- Society of Cable telecommunications Engineers, Inc., Document #IPS-SP-001, Flexible RF Coaxial Dropcable Specification
- TIA-492AAAC, Detail specification for 850-nm laser-optimized, 50-µm core diameter/125-µm cladding diameter class 1a graded-index multimode optical fibers
The organizations listed below can be contacted to obtain reference information.

ANSI
   American National Standards Institute (ANSI) 11 W 42 St.
   New York, NY  10032
   USA
   (212) 642-4900

ASTM
   American Society for Testing and Materials (ASTM)
   100 Barr Harbor Drive
   West Conshohocken, PA  19428-2959
   USA
   (610) 832-9500

BICSI
   BICSI
   8610 Hidden River Parkway
   Tampa, FL 33637-1000
   USA
   (800) 242-7405

CSA
   Canadian Standards Association (CSA)
   178 Rexdale Blvd.
   Etobicoke, (Toronto), Ontario
   Canada M9W 1R3
   (416) 747-4363

EIA
   Electronic Industries Alliance (EIA)
   2500 Wilson Blvd., Suite 400
   Arlington, VA  22201-3836
   USA
   (703) 907-7500

FCC
   Federal Communications Commission (FCC)
   Washington, DC  20554
   USA
   (301) 725-1585

Federal and Military Specifications
   US Department of Commerce
NOTE: Also obtainable from ANSI

NEMA
National Electrical Manufacturers Association (NEMA)
1300 N. 17th Street, Suite 1847
Rosslyn, VA 22209
USA
(703) 841-3200

NFPA
National Fire Protection Association
Batterymarch Park
Quincy, MA 02269
USA
(617) 770-3000

SCTE
Society of Cable Telecommunications Engineers
140 Philips Rd.
Exton, PA 19341-1318
USA
(800) 542-5040

TIA
Telecommunications Industry Association (TIA)
2500 Wilson Blvd., Suite 300
Arlington, VA 22201-3836
USA
(703) 907-7700

Telcordia
One Telcordia Drive
Piscataway, NJ 08854-4157
USA
(732) 699-2000

UL
Underwriters Laboratories, Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062
USA
(312) 272-8800
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