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TIA STANDARD

Telecommunications Pathways and Spaces

TIA-569-C

May 2012

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TELECOMMUNICATIONS PATHWAYS AND SPACES

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FOREWORD

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

This Standard was developed by TIA Subcommittee TR-42.3.

Approval of this Standard

This Standard was approved by TIA Subcommittee TR-42.3, TIA Engineering Committee TR-42, and the American National Standards Institute (ANSI).

ANSI/TIA reviews standards every 5 years. At that time, standards are reaffirmed, withdrawn, or revised according to the submitted updates.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 40 organizations within the telecommunications industry (including manufacturers, consultants, end users and other organizations) contributed their expertise to the development of this Standard.

Documents superseded

This Standard replaces TIA-569-B dated October, 2004, and its addendum. Content specific to commercial building pathways and spaces can be found in ANSI/TIA-568-C.1. Content specific to outside plant entrance facilities, including entrance points and entrance pathways, can be found in ANSI/TIA-758-B. References to earlier versions of this Standard may require further reference to these documents.

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. Figure 1 shows the schematic relationship between TIA telecommunications cabling standards.

- *Generic Telecommunications Cabling for Customer Premises* (ANSI/TIA-568-C.0);
- *Commercial Building Telecommunications Cabling Standard* (ANSI/TIA-568-C.1);
- *Balanced Twisted-Pair Telecommunications Cabling and Components Standard* (ANSI/TIA-568-C.2);
- *Optical Fiber Cabling Components Standard* (ANSI/TIA-568-C.3);
- *Residential Telecommunications Infrastructure Standard* (ANSI/TIA-570-B);
- *Administration Standard for Commercial Telecommunications Infrastructure* (ANSI/TIA/EIA-606-A);
- *Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises* (ANSI/TIA-607-B);
- *Customer-owned Outside Plant Telecommunications Infrastructure Standard* (ANSI/TIA-758-B);
- *Building Automation Systems Cabling Standard for Commercial Buildings* (ANSI/TIA/-862-A);
- *Telecommunications Infrastructure Standard for Data Centers* (ANSI/TIA-942); and

- *Telecommunications Infrastructure Standard for Industrial Premises* (ANSI/TIA-1005).

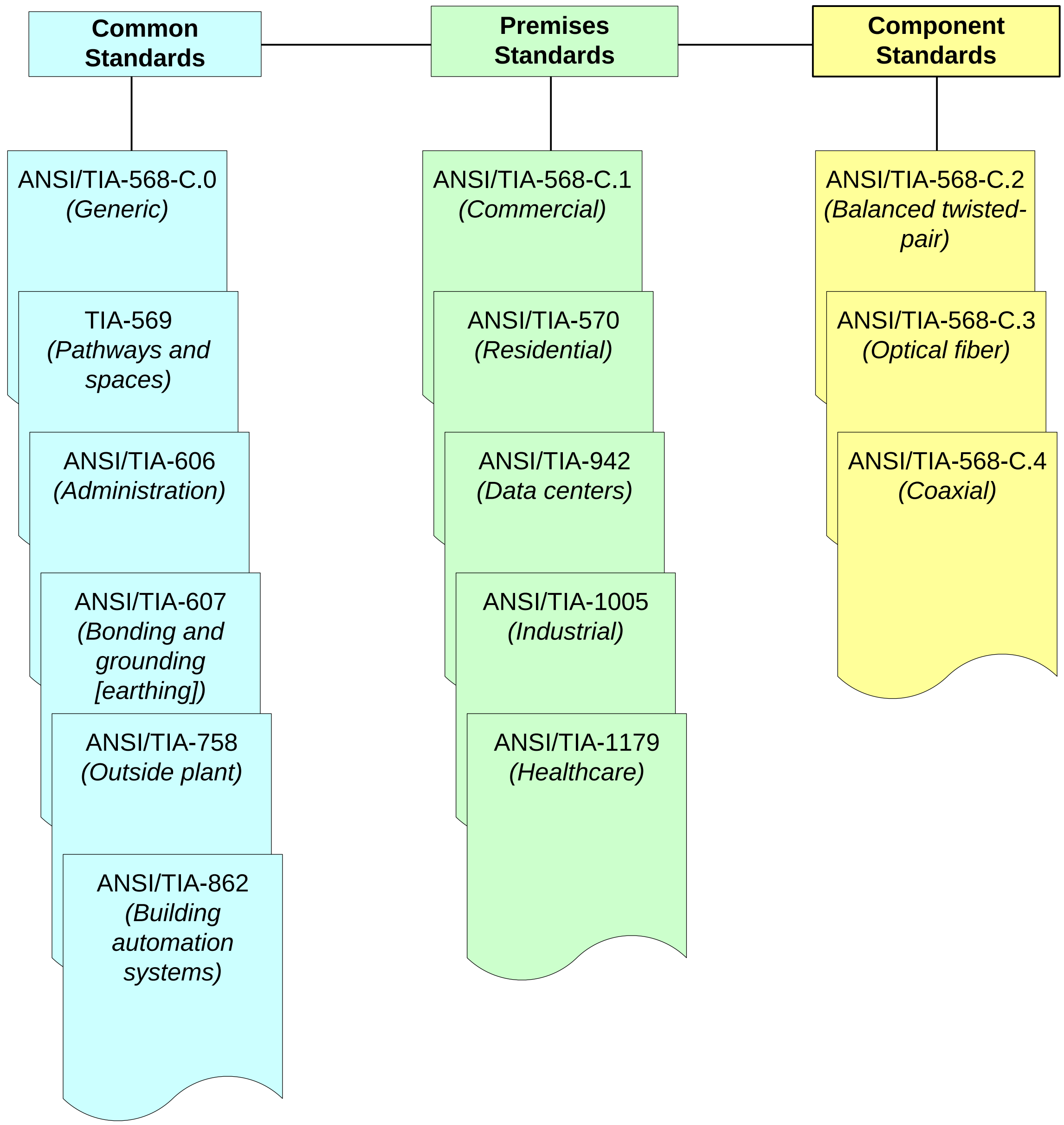

Figure 1 – Relationship between relevant TIA standards

The following documents may be useful to the reader:

- *National Electrical Safety Code®* (IEEE C2-2007); and
- *National Electrical Code® (NEC®)* (NFPA 70-2011)

Useful supplements to this Standard are the following BICSI documents: the *Telecommunications Distribution Methods Manual*, the *Outside Plant Design Manual*, and the *Information Transport Systems Installation Methods 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

This Standard has three annexes. Annex A is normative and considered a requirement of this Standard. Annexes B and C are informative and not considered a requirement of this Standard.

Introduction

This Standard recognizes three fundamental concepts related to telecommunications and buildings:

- Buildings are dynamic. Over the life of a building, remodeling is more the rule than the exception. This Standard recognizes, in a positive way, that change takes place.
- Building telecommunications systems and media are dynamic. Over the life of a building, both telecommunications equipment and media change. This Standard recognizes this fact by maintaining independence from specific vendor equipment and media.
- Telecommunications is comprised of more than just voice and data. Telecommunications also encompasses many other building systems including environmental control, security, audio, television, sensing, alarms and paging. Indeed, telecommunications embraces all wired and wireless means of conveying information within buildings.

This Standard also recognizes an important precept: in order to have a building successfully designed, constructed, and provisioned for telecommunications, it is imperative that the telecommunications design be incorporated during the preliminary architectural design phase, and reviewed throughout construction.

Both architectural and telecommunications terminology are used in this Standard, which may cause some difficulty to readers experienced in one area but perhaps not in the other. The reader can reduce confusion by remembering that this Standard does not standardize the media or equipment; it only standardizes the pathways and spaces up to and within buildings into which telecommunications media and equipment are placed.

This Standard recognizes the evolving nature of building tenant needs, the building's inherent limitations in adapting to changing tenant needs once the building has been constructed, and the special attention to telecommunications pathways and spaces design necessitated during the initial planning stages of new building designs.

This Standard recognizes that floor space is occupied by each tenant, which usually occurs after the building has been provisioned. In a multi-tenant building the build out design of the tenant space may include telecommunications pathways and spaces, in addition to the base building design, to accommodate distinct tenant needs. It is expected that, at the time of occupancy, individual tenants will design their telecommunications infrastructure in conformance with ANSI/TIA-569-C and the relevant premises standard (see figure 1). As a result, the build-out design may also include pathways and spaces to support a two-level cabling hierarchy for each tenant.

Multi-tenant buildings have life cycles that mirror that of single-tenant buildings. Many buildings are over 100 years old. Over time, these older buildings have become severely challenged to support escalating demands on their pathways and spaces as a result of tenants' ever increasing needs for telecommunications connectivity.

Telecommunications pathways and spaces in multi-tenant buildings are further challenged by the phased nature of their use. After the building is constructed and the first group of tenants move in, the tenant's telecommunications needs may immediately cause modifications to the building. Over a span of years, as tenants cycle through the building, evolving tenant needs will continue to force the building to adapt to the demands of its tenants.

Although the scope is limited only to the telecommunications aspect of building design, this Standard significantly influences the design of other building services, such as electrical power and HVAC. It also sets minimum requirements for the size of telecommunications spaces.

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.

Purpose

The purpose of this Standard is to standardize specific pathway and space design and construction practices in support of telecommunications media and equipment within buildings.

Expected usefulness

A principal goal of this Standard is to be useful to the building owners and occupants who otherwise would live with the daily problems associated with buildings that are not properly designed and constructed to support telecommunications. A properly designed and constructed facility is adaptable to change over the life of the facility. Owners and occupants should assume that better telecommunications facilities are constructed through the use of this Standard. Indeed, part of the expected usefulness of this Standard is that it be referenced in documents such as bid requests, specifications, and contracts leading up to the construction of the facilities.

This Standard should also prove useful to the team that is responsible for delivering a well-designed facility to the owner – the architects, engineers, and the construction industry. A good understanding of this Standard by this team will significantly reduce unforeseen problems associated with the telecommunications infrastructure. Two organizations, in particular, are lauded for their supportive role as this Standard was initially developed – the American Institute of Architects (AIA) and the Construction Specifications Institute (CSI).

Other organizations will also benefit from an understanding of the Standard. In particular, the Building Owners and Managers Association (BOMA), BICSI, a telecommunications association, and the International Facility Management Association (IFMA) will find this Standard closely aligned with their goals for good building design and construction.

This Standard generally makes no specific recommendations among the design alternatives available for telecommunications pathways and spaces. For example, the choice between a conduit system versus a tray system is not delineated. It is up to the telecommunications designer to properly select among the alternatives based upon the applications at hand and the constraints imposed. Readers, especially end users and owners, should ensure that qualified designers of telecommunications pathways and spaces are selected to implement this standard.

Specification of criteria

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 criteria generally apply to protection, performance, administration and compatibility; they specify minimally acceptable requirements. Advisory criteria are presented when their attainment may enhance the general performance of the cabling system in all its contemplated applications.

A note in the text, table, or figure is used for emphasis or offering informative suggestions, or providing additional information.

Metric equivalents of US customary units

The units of measure in this Standard are metric or US customary with soft conversion between the two.

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.

Basic building elements

Telecommunications has an impact on most every area within and between buildings. Because of this, and the additional fact that the useful life of a building may span many decades, it is important that the design and construction of new or remodeled buildings be performed with an objective of avoiding obsolescence. When a building is designed with its life cycle in mind, the resulting building will be responsive to the many changes that occur in both telecommunications media and systems over the life of the building.

Figure 2 illustrates the relationships between the major telecommunications pathway and space elements within a building. The list of these elements that follow the figure describes the characteristics of each element; numbers are keyed to respective sections within this Standard.

Figure 3 is a representative model of the various functional elements that comprise multi-tenant pathways and spaces in a building; this is not intended to be an all inclusive representation. It depicts the relationship between the elements and how they are configured to create a total system.

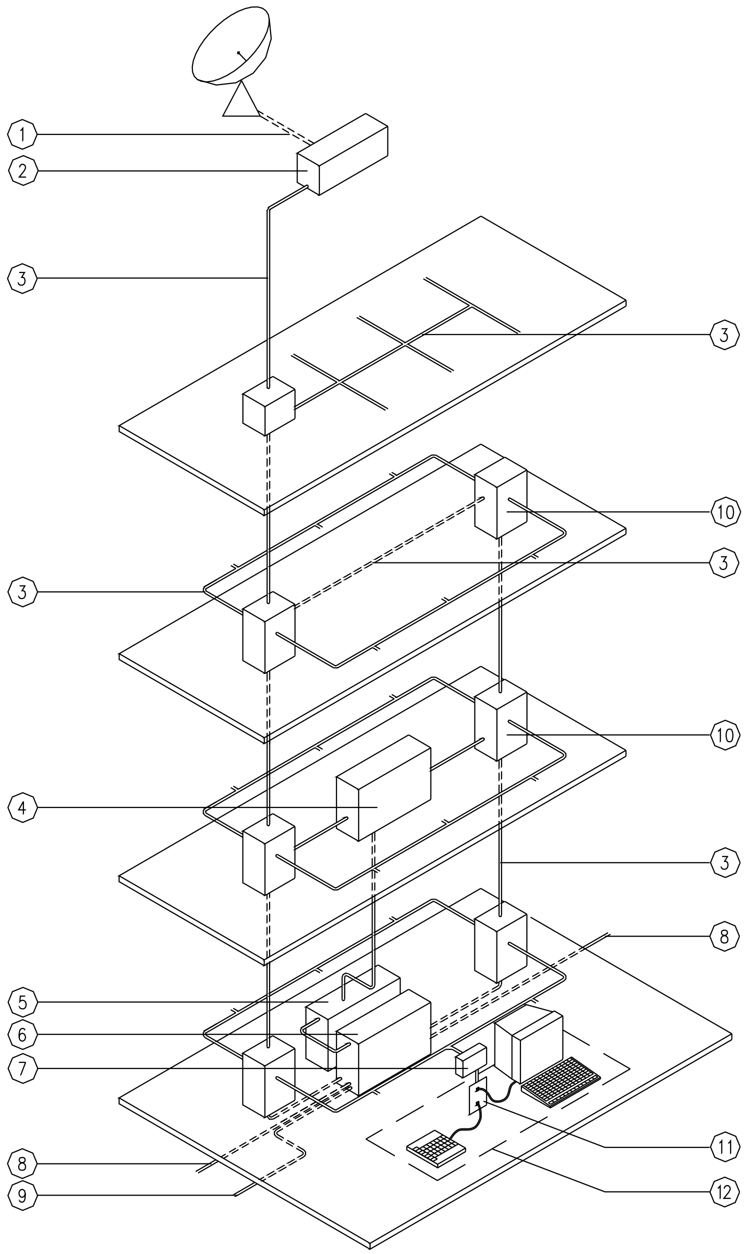

Figure 2 – Example of pathways and spaces in a single-tenant building

	Description	Clause or subclause		Description	Clause or subclause
1	Wireless service entrance pathway	6.5.2	7	Distributor enclosure	6.6
2	Entrance room	6.5	8	Service entrance pathway	6.5.2
3	Building pathways	9	9	Diversity of entrance routes	5.5
4	Distributor room	6.3.10	10	Distributor room	6.3.10
5	Access provider space, service provider space	7	11	Equipment outlet	6.6
6	Entrance room	6.5	12	Equipment outlet location	6.7.3

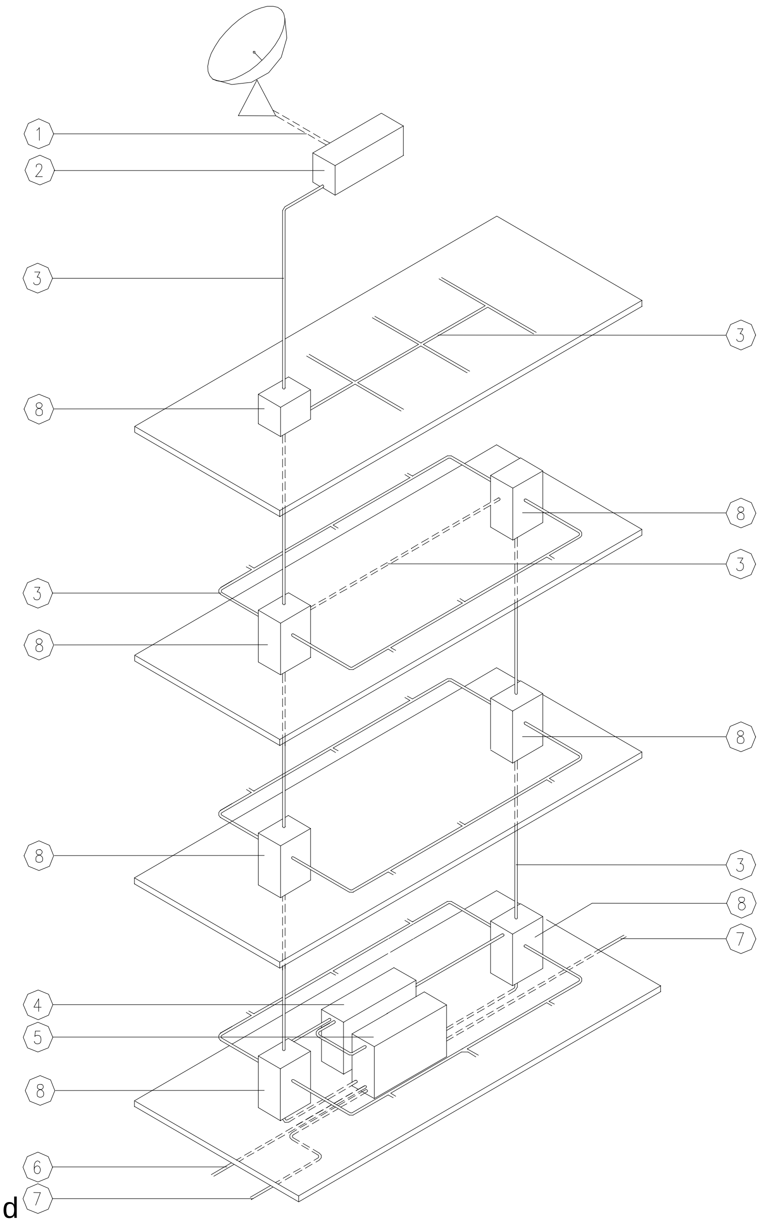

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Figure 3 – Example of common pathways and spaces in a multi-tenant building

	Description	Clause or subclause		Description	Clause or subclause
1	Wireless service entrance pathway	6.5.2	5	Entrance room	6.5
2	Entrance room	6.5	6	Service entrance pathway	6.5.2
3	Common building pathways	9	7	Diversity of entrance routes	5.5
4	Access provider space, service provider space	7	8	Common distributor room	8.2

1 SCOPE

This standard specifies requirements for telecommunications pathways and spaces.

> **NOTE –** The diversity of services currently available, coupled with the continual addition of new services, means that there may be cases where limitations to desired performance occur. When applying specific applications to the infrastructure described in this Standard, the user is cautioned to consult application standards, regulations, equipment vendors, and system and service suppliers for applicability, limitations, and ancillary requirements.

2 NORMATIVE REFERENCES

The following standards contain provisions which, 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 indicated below. ANSI and TIA maintain registers of currently valid national standards published by them.

- ANSI C95.2-1999, *Standard for Radio Frequency Energy and Current Flow Symbols*
- ANSI/IEEE 1100-2005, *IEEE Recommended Practice for Powering and Grounding Electronic Equipment (IEEE Emerald Book)*
- ANSI/TIA-607-B 2011, *Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises*
- ANSI/NEMA OS 1-2008, *Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports*
- ANSI/NFPA 13 2010, *Standard for the Installation of Sprinkler Systems*
- ANSI/TIA-568-C.0 2009, *Generic Telecommunications Cabling for Customer Premises*
- ANSI/TIA-568-C.2 2009, *Balanced Twisted-Pair Telecommunications Cabling and Components Standard*
- ANSI/TIA-758-B 2011, *Customer-owned Outside Plant Telecommunications Infrastructure Standard*
- ANSI/UL 1479 2003, *Standard for Fire Tests of Through-Penetration Firestops*
- ASHRAE, *Thermal Guidelines for Data Processing Environments, Second Edition,* 2009
- ASHRAE, *2011 Thermal Guidelines for Data Processing Environments – Expanded Data Center Classes and Usage Guidance*, 2011
- ASTM E119-10b 2010, *Standard Test Methods for Fire Tests of Building Construction and Materials*
- ASTM E814-10 2010, *Standard Test Method for Fire Tests of Penetration Firestop Systems*
- ATIS 0600336 2009, *Engineering Requirements for a Universal Telecom Framework*
- BICSI *Telecommunications Distribution Methods Manual (TDMM),* 12th Edition, 2009
- CISCA *Recommended Test Procedures for Access Floors,* 2007
- EIA/ECA-310-E 2005, *Cabinets, Racks, Panels, and Associated Equipment*
- FCC OET Bulletin 65, *Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields*, Edition 97-01
- IEC 61000-4-4 2004, *Electromagnetic Compatibility (EMC) – Part 4-4: Testing and Measurement Techniques – Electrical Fast Transient/Burst Immunity Test*
- NEMA VE 2-2006, *Cable Tray Installation Guidelines*
- NFPA 70 2011, *National Electrical Code© (NEC©)*

3 DEFINITIONS, ACRONYMS AND ABBREVIATIONS, 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.

ablative: The development of a hard char that resists the erosion of fire and flames; a characteristic of a firestop when exposed to fire.

access floor: A system consisting of completely removable and interchangeable floor panels that are supported on adjustable pedestals or stringers (or both) to allow access to the area beneath.

access provider: The operator of any facility that is used to convey telecommunications signals to and from a customer premises.

access unit: A location that allows entry into the pathway system.

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

balance: The ratio of the differential signal output at either end of any pair to a common mode signal input, at either end of the same or a different pair, and vice versa, under specified termination conditions.

barrier (architectural): Architectural structures or assemblies.

blank cell: The hollow space of a cellular metal or cellular concrete floor unit without factory installed fittings.

bonding: The joining of metallic parts to form an electrically conductive path.

building automation system: Equipment and telecommunications infrastructure that supports monitoring, control, operation and management of building services.

building core: A three-dimensional space permeating one or more floors of the building and used for the extension and distribution of utility services (e.g., elevators, washrooms, stairwells, mechanical and electrical systems, and telecommunications) throughout the building.

bundled cable: An assembly of two or more cables continuously bound together to form a single unit.

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

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 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.

> **NOTE –** See figure 4 for an illustration of the generic cabling topology for Cabling Subsystem 1, Cabling Subsystem 2, Cabling Subsystem 3, Distributor A, Distributor B, Distributor C, an optional consolidation point and the equipment outlet.

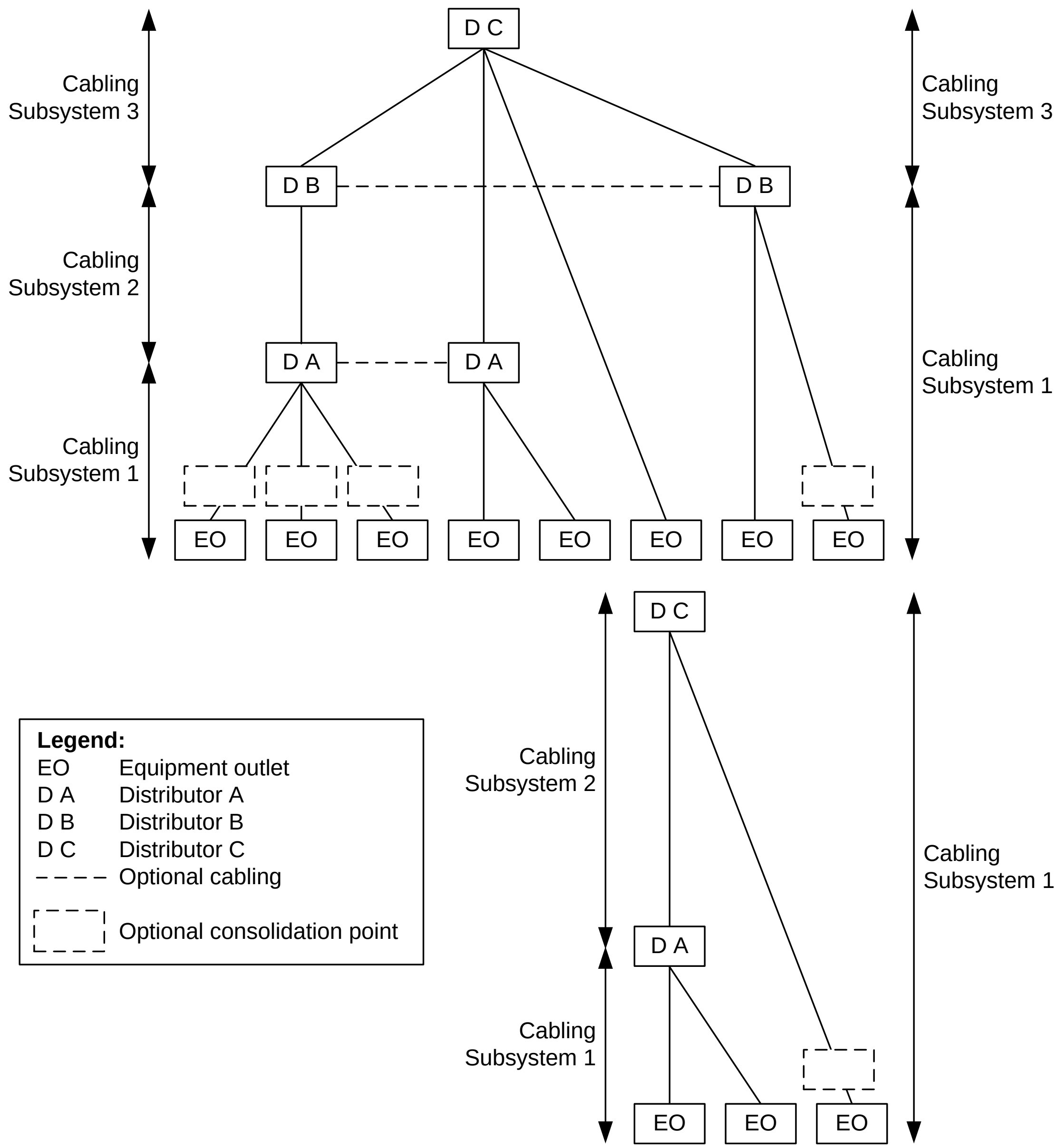


Figure 4 – Elements of generic cabling topology

campus: The buildings and grounds having legal contiguous interconnection.

cell: A single raceway of a cellular or underfloor duct system.

cellular floor: A floor distribution method in which cables pass through floor cells, constructed of steel or concrete to provide a ready-made raceway for distribution of power and telecommunications cables.

cementitious firestop: A firestopping material that is mixed with water, similar in appearance to mortar.

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

coaxial cable: A telecommunications cable consisting of a round center conductor surrounded by a dielectric surrounded by a concentric cylindrical conductor (shield) and an optional insulating sheath.

common distributor room: A distributor room that services tenants in a multi-tenant building.

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

> **NOTE –** For the purposes of this Standard the term conduit includes electrical metallic tubing (EMT) or electrical non-metallic tubing (ENT)

conduit sizes: For the purposes of this Standard, conduit sizes are designated according to metric designator and trade size as shown in table 1.

Table 1 – Conduit sizes

Metric designator	Trade size
16	½
21	¾
27	1
35	1¼
41	1½
53	2
63	2½
78	3
91	3½
103	4
129	5
155	6

connecting hardware: A device providing mechanical cable terminations.

consolidation point: A connection facility within Cabling Subsystem 1 for interconnection of cables extending from building pathways to the equipment outlet.

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.

dew point: the temperature to which air must be cooled (assuming constant air pressure and moisture content) to reach a relative humidity of 100% (i.e., saturation).

distribution duct: A raceway placed within or just below the finished floor and used to extend the wires or cables to a specific service area.

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

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

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

> **NOTE –** See figure 4 for an illustration of the generic cabling topology for Cabling Subsystem 1, Cabling Subsystem 2, Cabling Subsystem 3, Distributor A, Distributor B, Distributor C, an optional consolidation point and the equipment outlet.

distributor enclosure: A case or housing designed to contain Distributor A, Distributor B or Distributor C.

distributor room: An enclosed architectural space designed to contain Distributor A, Distributor B or Distributor C.

dry-bulb temperature: The temperature of air measured by a thermometer freely exposed to the air but shielded from radiation (e.g. sunlight, radiant heat) and moisture.

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, generally part of the HVAC system of a building, in which air is moved.

elastomeric firestop: A firestopping material resembling rubber.

electromagnetic interference: Radiated or conducted electromagnetic energy that has an undesirable effect on electronic equipment or signal transmissions.

embedded duct: A duct fully enclosed inside a floor or a wall.

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.

entrance room or space (telecommunications): A space in which the joining of inter or intra building telecommunications facilities takes place.

> **NOTE -** An entrance room may also serve as a distributor room.

equipment outlet: Outermost connection facility in a hierarchical star topology.

> **NOTE –** See figure 4 for an illustration of the generic cabling topology for Cabling Subsystem 1, Cabling Subsystem 2, Cabling Subsystem 3, Distributor A, Distributor B, Distributor C, an optional consolidation point and the equipment outlet.

feeder duct: See **header duct**.

fire resistance rating: The time in hours or fraction thereof that a material or assembly of materials will withstand the passage of flame and the transmission of heat when exposed to fire under specified conditions of test and performance criteria.

firestop: A fire-rated material, device, or assembly of parts installed in a penetration of a fire-rated barrier.

firestop seals: See **firestop system**.

firestop system: A specific construction consisting of the material(s) (firestop penetration seals) that fill the opening in the wall or floor assembly and any items that penetrate the wall or floor, such as cables, cable trays, conduit, ducts, pipes, and any termination devices, such as electrical outlet boxes, along with their means of support.

firestopping: The process of installing listed, fire-rated materials into penetrations in fire-rated barriers to reestablish the fire-resistance rating of the barrier.

flush duct: A duct accessible by a cover that is even with the surface it is mounted in.

furniture cluster: A contiguous group of work areas, typically including space divisions, work surfaces, storage, and seating.

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: the act of creating a ground.

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

header duct (trenchduct, feeder duct): A raceway of rectangular cross-section placed within the floor to tie distribution duct(s) or cell(s) to the distributor room.

hybrid cable: An assembly of two or more cables, of the same or different types or categories, covered by one overall sheath.

in-floor pathway: A raceway within a floor structure.

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

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

insert: An opening into the distribution duct or cell, from which the wires or cables emerge.

insert, afterset: An insert installed after the installation of the concrete floor slab or other flooring material.

insert, preset: An insert installed prior to the installation of the concrete floor slab or other flooring material.

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

intumescent firestop: A firestopping material that expands under the influence of heat.

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.

junction box: A location in the pathway system that allows transition of pathways and access to cables.

link: A transmission path between two points, not including equipment and cords.

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.

main distribution panel (electrical): The primary point of distribution for electrical services within a facility.

maintenance hole (telecommunications): A vault located in the ground or earth as part of an underground duct system and used to facilitate placing, connecting, and maintaining 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.

multi-user telecommunications outlet assembly: A grouping in one location of several telecommunications outlet/connectors.

optical fiber: Any filament made of dielectric materials that guides light.

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

outlet box (telecommunications): A housing used to hold telecommunications outlet/connectors.

outlet/connector (telecommunications): The fixed connector in an equipment outlet.

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.

permanent link: A test configuration for a link excluding test cords and patch cords.

plenum: A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.

poke-thru device: An assembly that allows through-penetration of floor decking with telecommunication cables, or power, or both, while maintaining the fire rating integrity of the floor.

pull box: A housing located in a pathway run used to facilitate the placing of wire or cables.

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

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

rack: Supporting frame equipped with side mounting rails to which equipment and hardware are mounted.

rack unit: Vertical mounting space of 1.75 in (44.45 mm) for cabinets or racks compliant with IEC 60297 or CEA-310-E.

screed line: The line to which poured concrete is leveled.

service area: A building space containing one or more equipment outlets (e.g., a work area or a coverage area).

service entrance: See **entrance facility (telecommunications)**.

service fitting: An outlet box to house the connections for telecommunications in the service area. See also **insert**.

service provider: The operator of any service that furnishes telecommunications content (transmissions) delivered over access provider facilities.

sheath: See **cable sheath**.

slab on grade: Concrete floor placed directly on soil, without basement or crawlspace.

sleeve: An opening, usually circular, through the wall, ceiling, or floor to allow the passage of cables.

slot: An opening through a wall, floor, or ceiling, usually rectangular, to allow the passage of cables.

space (telecommunications): An area used for housing the installation and termination of telecommunications equipment and cable.

suspended ceiling: A ceiling that creates an area or space between the ceiling material and the structure above.

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 room or space: See **entrance room or space (telecommunications).**

telecommunications infrastructure: See **infrastructure (telecommunications).**

telecommunications outlet: An assembly of components consisting of one or more connectors mounted on a faceplate, housing or supporting bracket.

transverse conversion loss: A ratio, expressed in dB, of the measured common mode voltage on a pair relative to the differential mode voltage on the same pair applied at the same end.

trenchduct: See **header duct**.

underfloor raceway: A pathway placed within the floor and from which wires and cables emerge to a specific floor area.

utility column: An enclosed pathway extending from the ceiling to furniture or to the floor, that forms a pathway for electrical wiring, telecommunications cable, or both.

wire: An individually insulated solid or stranded metallic conductor.

wireless: The use of radiated electromagnetic energy (e.g., radio frequency and microwave signals, light) traveling through space to convey information.

wireline: The use of conductors or optical fibers to transport information.

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

3.3 Acronyms and abbreviations

ADA	Americans with Disabilities Act
AHJ	authority having jurisdiction
AIA	American Institute of Architects
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	ASTM International, formerly American Society for Testing and Materials
AWG	American Wire Gauge
BAS	building automation system
BOMA	Building Owners Managers Association
CSI	Construction Specifications Institute
ECA	Electronic Components Association
EFT	electrical fast transient
EIA	Electronic Industries Alliance
EMI	electromagnetic interference
FCC	Federal Communications Commission
HVAC	heating, ventilation and air conditioning
ICEA	Insulated Cable Engineers Association
IEC	International Electrotechnical Commission
IFMA	International Facility Management Association
MDP	main distribution panel
MUTOA	multi-user telecommunications outlet assembly
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NIC	network interface card
NRTL	national recognized testing laboratory
PVC	polyvinyl chloride
RH	relative humidity
ScTP	screened twisted-pair
TCL	transverse conversion loss
TIA	Telecommunications Industry Association
UL	Underwriters Laboratories Inc
UPS	uninterruptable power supply
UTP	unshielded twisted-pair
UV	ultraviolet

3.4 Units of measure

A	ampere
dB	decibel
°C	degrees Celsius
°F	degrees Fahrenheit
ft	feet, foot
in	inch
kg	kilogram
kVA	kilovoltamp
lb	pound
lbf	pound-force
m	meter
µg	microgram
mm	millimeter
ms	millisecond
ns	nanosecond
V	volts
Vac	volts alternating current

4 ENVIRONMENTAL COMPATIBILITY

Pathways and spaces should be designed to be compatible with the worst case environment to which they will be exposed. Compatibility with the environment can be achieved with enhanced components or by means of separation or isolation. Separation and isolation methods can be used to convert the environment to be compatible with the pathways and spaces. In some cases, a combination of component enhancements, isolation and separation may be used. See ANSI/TIA-568-C.0 and TSB-185 for information on environmental classifications.

5 DIVERSITY OF TELECOMMUNICATIONS FACILITIES

5.1 General

Buildings that are equipped with diverse telecommunications facilities may be able to continue telecommunications operation under catastrophic conditions that would otherwise interrupt the building's telecommunications service. While diversity of telecommunications can be developed most efficiently during the design phase of a project, it should also be considered after the completion of construction, especially where continuity of telecommunications service is a critical element of a tenant's operation.

5.2 Access provider

Construction of more than one access provider space within a building encourages the presence of multiple access providers. When more than one access provider serves a building, disruption in one access provider's facilities will not interrupt the entirety of a building's telecommunications service.

5.3 Wireline/wireless

By developing multiple facilities (such as wireline and wireless) to serve a building, a disruption in one reduces the chances for interruption of all telecommunications service.

5.4 Entrance point

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. For information on diversity of entrance points see ANSI/TIA-758-B.

5.5 Entrance route

By developing diverse building entrance routes, a catastrophic failure along one entrance route will not interrupt the entirety of a building's telecommunications service. For information on diversity of entrance routes see ANSI/TIA-758-B.

5.6 Building pathways

By developing more than one building pathway system, a building pathway design can accommodate a catastrophic failure that may occur along the route of one of the building pathways. When diverse building pathways are developed, they should be separated from one another by the greatest practical distance and, wherever possible, should not pass through the same room.

5.7 Building spaces

Developing more than one building space may prevent a catastrophic failure or complete disruption of service facility-wide within one space. When diverse building spaces are developed, they should be separated by the greatest practical distance.

6 BUILDING SPACES

6.1 General

Telecommunications spaces include a variety of rooms and locations that are used by a building's occupants to interact with telecommunications equipment, and are a location for the placement, termination, and interconnection of cabling and telecommunications equipment.

6.2 Temperature and humidity requirements

Table 2 – Temperature and humidity requirements for telecommunications spaces

ASHRAE Class	SPACE (see clause)	Environmental requirements
Class A1 Class A2 Class A3 Class A4	See note 1	• Temperature: 18 – 27 ºC (64 – 81 ºF) dry bulb ○ High altitude: reduce maximum dry-bulb temperature 1 ºC (1.8 ºF) for every 300 m (1000 ft) above 1800 m (5900 ft) altitude. • Maximum relative humidity (RH): 60% • Maximum dew point: 15 ºC (59 ºF) • Minimum dew point (lower moisture limit): 5.5 ºC (42 ºF)[2] • Maximum rate of temperature change: 5 ºC (9 ºF) per hour
Class B	Distributor room (6.4) Distributor enclosure (6.6) Entrance room or space (6.5) Access provider space (7) Service provider space (7) Common distributor room (8.2)	• Temperature: 5 – 35 ºC (41 – 95 ºF) dry bulb ○ High altitude: reduce maximum dry-bulb temperature 1 ºC (1.8 ºF) for every 300 m (1000 ft) above 900 m (3000 ft) altitude. ○ Diskettes: minimum temperature with diskette in a drive is 10 ºC (50 ºF). • Relative humidity (RH): 8 – 80% • Maximum dew point: 28 ºC (82 ºF)
Class C	See note 1	• Temperature: 5 – 40 ºC (41 – 104 ºF) dry bulb ○ High altitude: reduce maximum dry-bulb temperature 1 ºC (1.8 ºF) for every 300 m (1000 ft) above 900 m (3000 ft) altitude. ○ Diskettes: minimum temperature with diskette in a drive is 10 ºC (50 ºF). • Relative humidity (RH): 8 – 80% • Maximum dew point: 28 ºC (82 ºF)

NOTES:

1. Class A1, Class A2. Class A3, Class A4 and Class C are not referenced by this Standard. They are included for reference by specific premises standards.
2. Dew point of 5.5 ºC (42 ºF) corresponds to approximately 44% RH at 18 ºC (64 ºF) and 25% RH at 27 ºC (81 ºF).

Temperature and humidity in telecommunications spaces shall be controlled to provide continuous operating ranges for their designated ASHRAE classes as specified in table 2. See the ASHRAE *Thermal Guidelines for Data Processing Environments* and ASHRAE *2011 Thermal Guidelines for Data Processing Environments – Expanded Data Center Classes and Usage Guidance* for more information on ASHRAE classes.

The temperature and humidity shall be measured while the equipment is in operation. Temperature and humidity shall be measured at air intakes of operating (powered) equipment. Except in equipment enclosures, temperature and humidity should also be measured at a distance of 1.5 m (5 ft) above the floor level every 3 to 9 m (10 to 30 ft) along the center line of the aisles at the front of the cabinets or racks. In equipment enclosures the temperature and humidity should also be measured as near as practical to the center of the enclosure. Temperature measurements should be taken at several locations of the air intake of any equipment with potential cooling problems. Refer to *ASHRAE Thermal Guidelines for Data Processing Equipment* and *2008 ASHRAE Environmental Guidelines for Datacom Equipment – Expanding the Recommended Environmental Envelope* for more detailed guidelines for measuring and evaluating equipment room temperatures.

6.3 Common requirements for rooms

6.3.1 General

The requirements of 6.3 apply to the following telecommunications spaces:

a) distributor room;
b) common distributor room;
c) entrance room or space;
d) access provider space; and
e) service provider space.

These requirements may also apply to other telecommunications spaces as referenced by specific premises standards.

6.3.2 Security

The design and location of the telecommunications space should be developed in accordance with the security plan of the building.

6.3.3 Location

When selecting the site, avoid locations that are restricted by building components that limit expansion such as elevators, core, outside walls, or other fixed building walls. Accessibility for the delivery of large equipment should be provided (see 6.3.10).

The telecommunications space should be located away from sources of electromagnetic interference or designed to mitigate the effects of this interference (see clause 4). Special attention shall be given to electrical power supply transformers, motors and generators, X-ray equipment, radio or radar transmitters, and induction sealing devices.

6.3.4 Access

The room should be located in an accessible area (e.g., a common hallway). Access to the space shall be controlled by the building owner or agent.

6.3.5 Pathways

Sleeves or slots shall not be left open except during cable installation and shall be properly fire-stopped (see Annex A) per applicable codes.

6.3.6 Design

6.3.6.1 Architectural

6.3.6.1.1 Plywood backboards

A minimum of one wall shall be covered with 19 mm (3/4 in) plywood. The backboard shall be 1.2 m (4 ft) x 2.4 m (8 ft) sheets, mounted vertically, with the bottom of the plywood mounted 150 mm (6 in) above the finished floor with the best side toward the room. Plywood shall be A/C grade and finished with two coats of fire-retardant paint. Plywood shall be painted prior to installation of any equipment. Plywood shall be permanently fastened to the wall by means of wall anchors utilizing galvanized, zinc plated, or stainless steel hardware with a flat head. Finished installation shall have flush appearance with countersunk screw heads to prevent splitting of the plywood. Drywall screws are not acceptable.

6.3.6.1.2 Ceiling

Minimum clear height in the space shall be 2.4 m (8 ft) without obstructions. The height between the finished floor and the lowest point of the ceiling should be a minimum of 3 m (10 ft) to accommodate taller frames and overhead pathways.

For maximum flexibility, false (suspended) ceiling should not be provided.

6.3.6.1.3 Treatment

Floors, walls, and ceiling shall be treated to minimize dust. Finishes shall be light in color to enhance room lighting. Floors shall have anti-static properties.

6.3.6.1.4 Floor loading

Floor loading (static and dynamic) capacity in the space shall be sufficient to bear both the distributed and concentrated load of the installed equipment. A structural engineer shall be consulted during the design to specify the floor loading limit. If equipment that exceeds these limits is anticipated, the floors for the areas where the equipment will be moved and installed shall be appropriately reinforced.

6.3.6.1.5 Lighting

When space is occupied by personnel, lighting shall be a minimum of 500 lux in the horizontal plane and 200 lux in the vertical plane, measured 1 m (3 ft) above the finished floor in the middle of all aisles between cabinets and racks. The lighting shall be controlled by one or more switches located inside the room near the entrance door(s). Emergency lighting and signs shall be properly placed per AHJ such that an absence of primary lighting will not hamper emergency exit.

Lighting fixtures should not be powered from the same electrical distribution panel as the telecommunications equipment in the space. Dimmer switches should not be used.

6.3.6.1.6 Door

The door shall be a minimum of 0.9 m (36 in) wide and 2 m (80 in) high, with no doorsill, hinged to open outward (code permitting), slide side-to-side, or be removable. The door shall be fitted with a lock. If it is anticipated that large equipment will be delivered to the entrance room, a double door 1.8 m (72 in) wide by 2.3 m (90 in) high, with no doorsill or center post, is recommended. If the door must open inwards, the size of the room (floor space) should be increased accordingly.

6.3.6.1.7 Signage

Signage, if used, should be developed within the security plan of the building.

6.3.6.1.8 Exterior windows

The telecommunications space should not have exterior windows, as exterior windows may increase heat load.

6.3.6.1.9 Seismic considerations

Seismic specifications for telecommunications infrastructure and related facilities shall accommodate applicable seismic requirements per the AHJ.

6.3.6.2 Environmental

6.3.6.2.1 Temperature and humidity

The temperature and humidity in the telecommunications space shall meet the requirements for ASHRAE Class B in 6.2.

6.3.6.2.2 Contaminants

Telecommunications building spaces shall be protected from contaminants and pollutants that could affect operation and material integrity of the installed equipment (see ANSI/TIA-568-C.0). The level of contaminants can be reduced using barriers, positive room pressure, absolute filters or other means.

6.3.6.2.3 Batteries

If non-sealed batteries are used for backup, adequate ventilation shall be provided. Refer to applicable electrical codes for requirements.

6.3.6.2.4 Vibration

Mechanical vibration coupled to equipment or the cabling infrastructure can lead to service failures over time. A common example of this type of failure would be loosened connections. Potential vibration problems should be considered in the design of the telecommunications spaces, since vibration within the building will exist and will be conveyed to the telecommunications building spaces via the building structure. In these cases, the project structural engineer should be consulted to design safeguards against excessive vibration.

6.3.6.3 Guidelines for other equipment

Environmental control equipment, such as power distribution or conditioner systems, and UPS up to 100 kVA that are dedicated for use by the telecommunications systems in the telecommunications space shall be permitted to be installed in that space. UPS larger than 100 kVA should be located in a separate room. When a UPS is installed in the room an appropriate notice should be posted on the exterior of the entrance door (e.g., "WARNING – Uninterruptible Power Supplies are in use in this area. Power will be present even in the event of a total building shutdown at the main service disconnect").

Equipment not related to the support of the telecommunications space (e.g., piping, ductwork, pneumatic tubing) shall not be installed in, pass through, or enter that room.

6.3.7 Fire protection

Fire protection shall be provided as per applicable code.

Consideration should be given to the installation of preaction sprinkler or other "dry" fire-suppression system for some applications. If wet pipe sprinklers are installed:

a) the heads shall be provided with wire cages to prevent accidental operation; and
b) drainage troughs shall be placed under the sprinkler pipes to prevent leakage onto the equipment within the room.

   NOTE – See NFPA 13 regarding preaction sprinklers, dry fire suppression systems, and wet pipe sprinklers.

6.3.8 Water infiltration

Telecommunications spaces shall not be located below water level unless preventive measures against water infiltration are employed. The telecommunications space shall be free of water or drain pipes not directly required in support of the equipment within the room. A floor drain with back flow preventer shall be provided within the room if risk of water ingress exists.

6.3.9 Racks and cabinets

6.3.9.1 General

Racks are equipped with side mounting rails to which equipment and hardware are mounted. Cabinets can be equipped with adjustable side mounting rails, side panels, a top, and front and rear doors, and are frequently equipped with locks.

6.3.9.2 Equipment placement

Active equipment designed for front to back air flow should be placed in cabinets and racks with "cold" air intake at the front of the cabinet or rack, and "hot" air exhaust out the back. To improve cooling efficiency and minimize recirculation blank panels should be installed in all unused rack and cabinet spaces.

6.3.9.3 Clearances

A minimum of 1 m (3 ft) of front clearance shall be provided for installation of equipment. A front clearance of 1.2 m (4 ft) is preferable to accommodate deeper equipment. A minimum of 0.6 m (2 ft) of rear clearance shall be provided for service access at the rear of racks and cabinets. A rear clearance of 1 m (3 ft) is preferable. Some equipment may require service clearances of greater than 1 m (3 ft). See equipment manufacturer requirements.

6.3.9.4 Cabinet cooling

Cabinets shall be selected and configured to provide adequate cooling for the equipment they will house. Adequate cooling can be achieved using a number of methods including:

a) forced airflow utilizing fans;
b) natural airflow between hot and cold aisles through ventilation openings in the front and rear doors of the cabinets;
c) hot aisle/cold isle cabinet arrangement;
d) installation of blanking panels and baffles in all open spaces between and around equipment;
e) sealing air leaks around all cable ingress points;
f) containment of cold or hot air flow streams;
g) using properly sized and located air conditioning units;
h) minimizing supply and return air flow obstructions;
i) balancing heat density across multiple cabinets; and
j) using liquid cooling.

6.3.9.5 Cabinet and rack height

The maximum rack and cabinet height shall be 2.4 m (8 ft). Racks and cabinets should preferably be no taller than 2.1 m (7 ft) for easier access to the equipment or connecting hardware installed at the top.

6.3.9.6 Cabinet depth and width

Cabinets should be of adequate depth to accommodate the planned equipment, including cabling at the front and/or rear, power cords, cable management hardware, and power strips. To ensure adequate airflow and to provide adequate space for power strips and cabling, consider using cabinets that are at least 150 mm (6 in) deeper or wider than the largest installed equipment.

6.3.9.7 Equipment mounting width

Racks and panels should provide mounting for 480 mm (19 in) patch panels and equipment.

6.3.9.8 Mounting rails

Racks and panels shall be equipped with mounting rails compliant with CEA-310-E.

Active equipment and connecting hardware should be mounted on the rails on rack unit boundaries to most efficiently utilize cabinet space and optimize cooling.

Cabinets should have adjustable front and rear rails. The rails should provide 42 or more rack units of mounting space. Rails should have markings at rack unit boundaries to simplify positioning of equipment.

If patch panels are to be installed on the front of cabinets, the front rails should be recessed at least 100 mm (4 in) to provide room for cable management between the patch panels and doors and to provide space for cabling between cabinets. Similarly, if patch panels are to be installed on the rear of cabinets, the rear rails should be recessed at least 100 mm (4 in).

Patch panels shall not be installed in a manner that prevents service access.

If power strips are to be installed on the front or rear rail of cabinets, adequate clearance should be provided for power cords and power supplies that may be installed on the power strips.

6.3.9.9 Finish

Painted finishes should be powder coat or other scratch-resistant finishes.

6.3.9.10 Power strips

Cabinets and racks with no active equipment do not require power strips.

The typical configuration for power strips in cabinets provides at least one 20 A, 120 Vac power strip. Depending on the planned equipment, 240 Vac power strips may be required in addition or instead of 120 Vac power strips. The use of two power strips that contain circuits that are fed from diverse power sources should be considered. Power circuits should have dedicated neutral and ground conductors. Power strips with indicators but no on/off switch or breaker reset button should be used to minimize accidental shut-off. A sufficient number of power strips should be used to provide enough receptacles and current capacity to support the planned equipment. The plug for the power strip should be a locking plug to prevent accidental disconnection.

6.3.9.11 Cable management

In order to ensure that vertical and horizontal cord managers are capable of accommodating the anticipated maximum density of cords, they should both be included during fill calculations.

A vertical cable manager shall be installed between each pair of racks and at both ends of every row of racks. Selection of vertical cable managers shall take into account maximum calculated fill including cord service loops, and wherever practical, providing for available cross-sectional area up to double the anticipated calculated fill needs. Vertical cord managers should extend from the floor to the top of the racks. The vertical cable managers shall be not less than 83 mm (3.25 in) in width.

Horizontal cord managers should be installed to accommodate maximum calculated fill requirements, and providing for a strategic growth factor of up to 100%. Cable management should be adequate to ensure that the cables can be neatly dressed and do not impair cooling, and that bend radius requirements specified in ANSI/TIA-568-C.0 are met.

6.3.9.12 Additional specifications

Refer to ATIS 0600336 for additional specifications for cabinets and racks.

6.3.10 Equipment delivery

Telecommunications equipment can be large, have considerable weight, and require special handling. Because of these factors, the following considerations are important in selecting the distributor room location. If some of these cannot be satisfied, the equipment can be shipped disassembled, which may result in a longer delivery interval and additional testing:

a) accessibility for equipment delivery;
b) driveway slope;
c) ramp slope;
d) Will stairwell be used? If so, can they hold the weight?;
e) Will such heavy weight cause problems with floor loading on floors leading to the equipment room?;

f) Will hoisting equipment be required?; and
g) width of hallways leading to the distributor room.

NOTE – Usually, the maximum tilt that a fully preassembled cabinet will accept is 8 degrees.

If heavy equipment is anticipated, the floor loading for the area where the equipment is installed and delivered shall be appropriately reinforced (see 6.3.6.1.4).

6.4 Distributor room

6.4.1 General

The distributor room is a common access point for cabling subsystems and building pathways. The distributor room shall be able to contain telecommunications equipment, cable terminations, and associated cross-connect cabling. The distributor room may also contain information technology equipment and building automation systems (BAS) equipment and cabling.

The distributor room shall be dedicated to the telecommunications function and related support facilities. The distributor room should not be shared with electrical installations other than those for telecommunications or associated equipment. Equipment not related to the support of the distributor room (e.g., piping, ductwork, pneumatic tubing) shall not be installed in, pass through, or enter the space.

The distributor room shall meet the requirements of 6.3 with additional requirements, exceptions and allowances as specified in 6.3.10.

6.4.2 Location

The distributor room shall be located as close as practicable to the center of the area served.

6.4.3 Pathways

A typical distributor room is shown in figure 5.

When multiple distributor rooms are located on the same floor, they should be interconnected by a minimum of one metric designator 78 (trade size 3) conduit or equivalent pathway.

The number and size of sleeves, slots or conduits shall be as determined per clause 9.

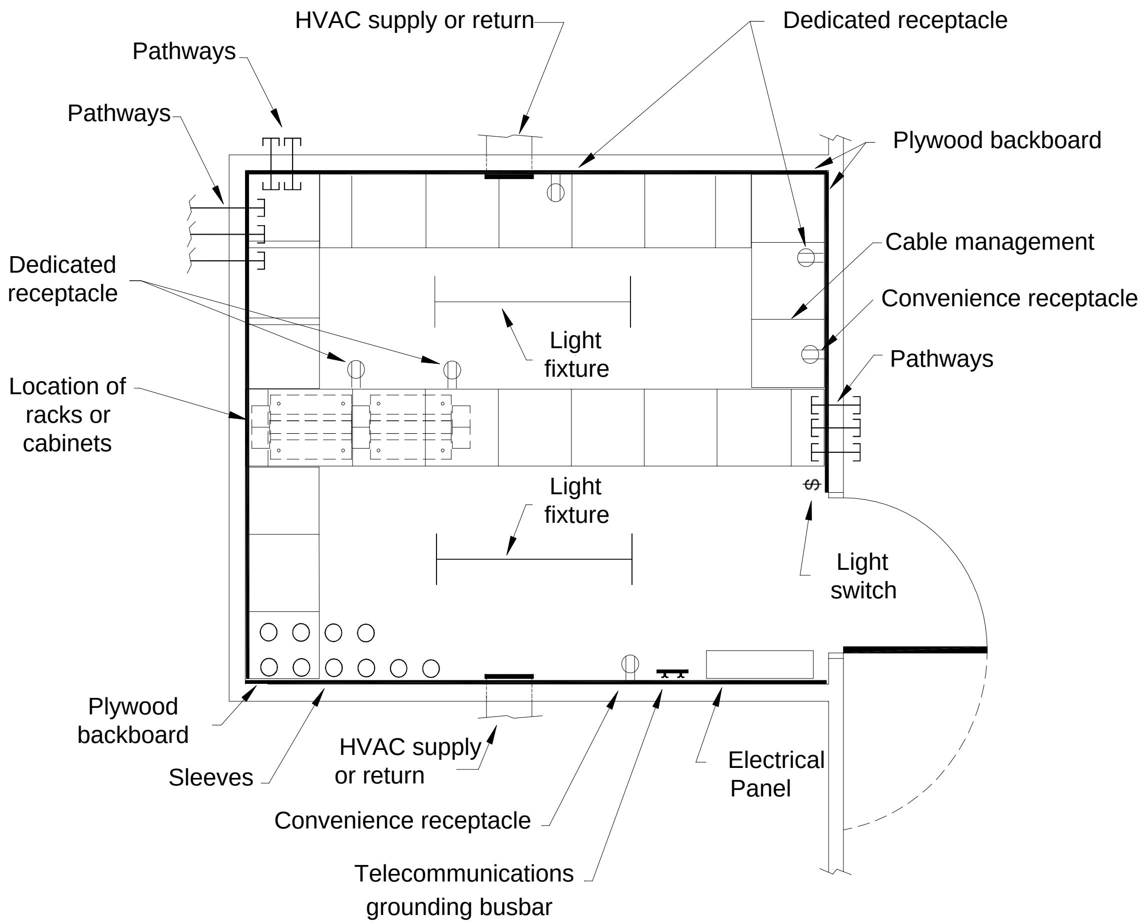


Figure 5 – Typical distributor room

6.4.4 Design

6.4.4.1 Architectural

6.4.4.1.1 Size

The distributor room shall be sized to meet the known requirements such as the function of the room, the numbers of equipment and equipment racks needed, and the number of equipment outlets that it will serve. Sizing shall include projected future as well as present requirements.

When designing the room floor space, allowance shall be made for non-uniform occupancy throughout the building.

Except as allowed in 6.4.5 or in premises standards, minimum floor space shall be based on the number of equipment outlets served directly (i.e., termination of Cabling Subsystem I) as shown in table 3 with a minimum dimension of 3 m (10 ft) for length and width.

A distributor room containing Distributor B should be sized at a minimum of 10 m^2 (100 ft^2).

A distributor room containing Distributor C should be sized at a minimum of 12 m^2 (120 ft^2) for building with gross area of up to 50 000 m^2 (500 000 ft^2). In larger buildings the size of the distributor room containing Distributor C should be increased in increments of 1 m^2 (10 ft^2) for every increase of 10 000 m^2 (100 000 ft^2) in gross building area.

Table 3 – Floor space

Equipment outlets served	Minimum floor space m^2 (ft^2)	Typical dimensions m (ft)
Up to 200	15 (150)	3 X 5 (10 X 15)
201 to 800	36 (400)	6 X 6 (20 X 20)
801 to 1600	72 (800)	6 X 12 (20 X 40)
1601 to 2400	108 (1200)	9 X 12 (30 X 40)

6.4.4.1.2 Quantity

There shall be a minimum of one distributor room per floor. Additional spaces may be required to respect the maximum cabling media distance requirements.

6.4.4.2 Environmental

6.4.4.2.1 Heating, ventilation and air conditioning (HVAC)

Environment control system shall be included in the design of the distributor room to maintain the required temperature and humidity(see 6.3.6.2.1).

6.4.4.2.1.1 Continuous operation

Planning for eventual provisioning, as required, of continuous HVAC (24 hours per day and 365 days per year) shall be included in the initial design. One means of providing around-the-clock HVAC is use of a stand-alone unit.

6.4.4.2.1.2 Standby operation

If a standby power source is available in the building, the HVAC system serving the distributor room should be connected to the standby supply.

6.4.4.2.1.3 Positive pressure

A positive pressure differential with respect to surrounding areas should be provided unless prohibited by the AHJ.

6.4.4.3 Electrical

6.4.4.3.1 Power

A minimum of two dedicated 120 Vac nominal, non-switched, ac duplex electrical receptacles, each on a separate branch circuit, shall be provided for equipment power. These receptacles should be rated at 20 A and shall be connected to a 20 A branch circuit. In addition, identified and marked convenience duplex outlets shall be placed at 1.8 m (6 ft) intervals around the perimeter walls, at a height of 150 mm (6 in) above the floor. Specific outlets for equipment and convenience along with their locations shall be coordinated with the telecommunications system designers.

> **NOTE –** In many cases, it is desirable that a dedicated power panel be installed to serve the telecommunications building spaces.

6.4.4.3.2 Standby power

If standby power is available, automatic switchover of power should be provided.

6.4.4.3.3 Bonding and grounding

A bonding and grounding system as specified by ANSI/TIA-607-B shall be provided.

6.4.5 Small rooms

Small rooms are not recommended. When used to serve areas up to 500 m^2, walk-in rooms should be a minimum of 1.3 m (4.5 ft) deep by 1.3 m (4.5 ft) wide and shallow rooms should be a minimum of 600 mm (24 in) deep by 2.6 m (8.5 ft) wide (see figure 6).

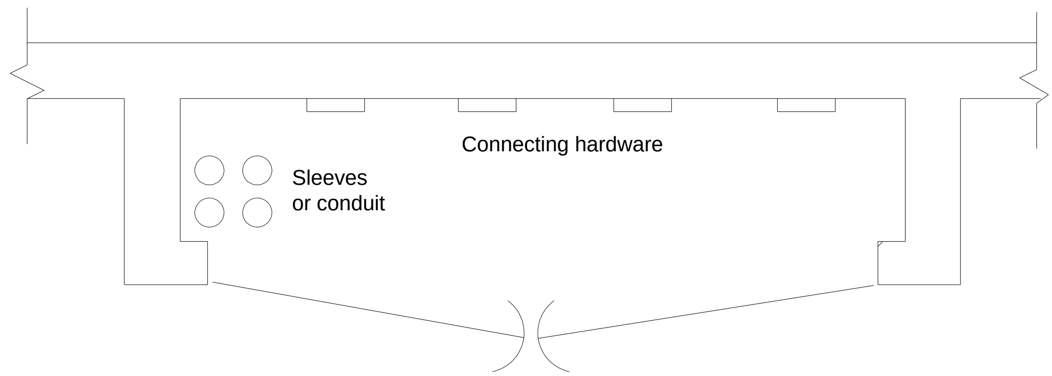


Figure 6 – Typical shallow room

6.5 Entrance room or space

6.5.1 General

The entrance room or space shall meet the requirements of 6.3 with additional requirements, exceptions and allowances as specified in 6.5.

6.5.2 Entrance facility

The entrance point to the building for outside plant cabling and the pathways from the entrance point to the entrance room shall meet the requirements of ANSI/TIA-758-B.

6.5.3 Location

The entrance room or space shall be located in a dry area not subject to flooding and should be as close as practicable to the building entrance point and next to the space containing the main distribution panel (MDP) in order to reduce the length of bonding conductor to the electrical grounding system.

The wireless transmission or reception entrance room shall be located as close as practicable to the wireless transmission or reception devices.

6.5.4 Design

6.5.4.1 Architectural

6.5.4.1.1 General

The decision whether a room or open area is provided shall be based on security, type of protectors, building size, and physical location within the building. For buildings exceeding 2000 m^2 (20 000 ft^2) usable floor space, an enclosed room should be provided.

6.5.4.1.2 Size

The entrance room or space shall be sized to meet the known requirements of Distributor C. Sizing shall include projected future as well as present requirements. The size of the termination frame or wall terminations is based on the quantity of cable to be terminated, which includes:

a) incoming service provider cables;
b) protectors;
c) campus cables; and
d) building cables.

In buildings with up to 10 000 m^2 (100 000 ft^2) of usable floor space, wall-mounted terminating hardware may be suitable. Buildings of larger floor area may require free-standing frames for cable terminations.

If network interface devices and telecommunications equipment are required in the entrance room or space, additional space will be needed. Where an entrance room or space is intended to be used for more than service provider termination (e.g., rack mounted equipment), it shall be increased in size accordingly. Where Distributor A, Distributor B or Distributor C is to be provided, the space shall be a minimum of 2.5 m (8 ft) wide and of sufficient length to house the floor-mounted free-standing frame.

6.5.4.1.3 Quantity

More than one entrance room or space may be required, depending upon building configuration and diversity of telecommunications issues. Where buildings are large or uniquely shaped, multiple entrance rooms or spaces may be mandated. See clause 4 regarding diversity of telecommunications.

6.5.4.2 Environmental

Temperature and humidity shall be controlled to meet the requirements of 6.3.6.2.1. More restrictive temperature and humidity operating ranges may be required by the providers of equipment in entrance rooms or spaces.

6.5.4.3 Electrical

6.5.4.3.1 Power

A minimum of two dedicated 120 Vac nominal, non-switched, ac duplex electrical receptacles, each on a separate branch circuit, shall be provided for equipment power. These receptacles should be rated at 20 A and shall be connected to 20 A branch circuit.

6.5.4.3.2 Bonding and grounding

A bonding and grounding system as specified by ANSI/TIA-607-B shall be provided.

6.6 Distributor enclosure

6.6.1 General

The distributor enclosure shall be dedicated to the telecommunications function and related support facilities. The distributor enclosure is a common access point for Cabling Subsystems and building pathways. The distributor enclosure shall be able to contain telecommunications equipment, cable terminations, and associated cross-connect cabling.

6.6.2 Location

The distributor enclosure shall be located as close as practicable to the center of the area served. Distributor enclosures shall not be installed in furniture systems unless that unit of furniture is permanently secured to the building structure.

6.6.3 Access

The distributor enclosures should be accessible and shall incorporate a means of security that discourages unauthorized entry.

6.6.4 Pathways

Pathways shall not pass through distributor enclosures. Cables that enter and exit the distributor enclosure shall be protected from sheath abrasion and conductor deformation by means of grommets, bushings, and suitable cable management hardware.

6.6.5 Design

6.6.5.1 Architectural

6.6.5.1.1 Size and spacing

The distributor enclosure should be sized to accommodate immediate requirements and foreseeable growth. Sufficient space within the distributor enclosure shall be provided to ensure compliance with cable bend radius limitations.

6.6.5.1.2 Interior provisioning

To facilitate the mounting of hardware, CEA-310-E compliant mounting holes should be installed where appropriate within the enclosure. Optionally, the distributor enclosure may be equipped with a plywood backboard that is secured to the back or side of the interior portion of the enclosure.

6.6.5.1.3 Lighting

Light, as measured within the distributor enclosure, should be a minimum of 500 lux. Lighting design should seek to minimize shadows within the distributor enclosure.

6.6.5.1.4 Door

The distributor enclosure door(s) may be hinged or removable. If the door(s) is hinged, the enclosure should be mounted so that the door(s) swings open a minimum of 90°, or otherwise provides unobstructed access to the inside of the enclosure, and remain open until manually closed. Sufficient working space shall be provided and maintained for a technician to gain unobstructed and safe access to the distributor enclosure.

6.6.5.1.5 Signage

Signage, if used, should be developed within the security plan of the building.

6.6.5.2 Environmental

Temperature and humidity in the distributor enclosure shall meet the requirements for ASHRAE Class B in 6.2.

6.6.5.3 Electrical

6.6.5.3.1 Power

A minimum of one dedicated 120 Vac nominal, non-switched, duplex electrical receptacle shall be provided. This receptacle should be rated at 20 A and be connected to a 20 A branch circuit. A duplex convenience outlet should be provided inside the enclosure and, when so provided, shall be on a separate branch circuit.

6.6.5.3.2 Standby power

If standby power is available, automatic switchover of power should be provided.

6.6.5.3.3 Bonding and grounding

If equipment or components in the enclosure need to be bonded to ground a bonding and grounding system compliant with ANSI/TIA-607-B shall be provided.

If the enclosure is comprised of metallic components, it shall be bonded to ground in accordance with the authority having jurisdiction.

6.6.6 Fire protection

Fire protection of the enclosures, if required, shall be provided as per applicable code.

6.7 Equipment outlets

6.7.1 General

Equipment outlets may be installed in a number of different spaces (e.g., outlet boxes, mounting brackets, poke-thru devices). The selection of the equipment outlet hardware is based on the applications, the service area that it serves and the premise environment type. For example, in a commercial environment where the equipment outlet is located in a work area, the hardware can be a telecommunications outlet or a MUTOA, but in a data center, the equipment outlet can be a patch panel or other connecting hardware.

6.7.2 Outlet density

A minimum of one equipment outlet space per serviced area shall be provided. For building areas where it is difficult to add equipment outlets at a later date, a minimum of two separate equipment outlet spaces should be provided in the initial design for that area.

6.7.3 Location

The location of equipment outlet spaces should be coordinated with the furniture or physical equipment layout.

When the equipment outlet is a telecommunications outlet a power outlet should be installed near each equipment outlet space (e.g., within 1 m (3 ft)). Equipment outlet spaces are typically at the same height as the power outlet.

When multiple equipment outlet spaces are provided for a given service area, they shall be located to offer maximum flexibility for change within the serviced area (e.g., on opposing walls in the space).

Specific service areas may require specific demands for telecommunications equipment. Independent and direct pathways shall be provided from these areas to the serving Distributors.

> **NOTE –** The federal Americans with Disabilities Act (ADA) may affect mounting locations in some instances.

6.7.4 Installation

Cabling system performance is sensitive to the arrangement of slack cable behind the equipment outlet. Sufficient space shall be provided so that bend radius requirements are not violated in these termination spaces. The location, mounting, and strain relief of the equipment outlet should allow pathway covers and trim to be removed without disturbing the cable termination. Equipment outlets should be mounted in such a way that they do not reduce the required pathway cabling capacity.

6.7.5 Outlet box

If an outlet box is used, it shall be no smaller than 50 mm (2 in) wide, 75 mm (3 in) high, and 64 mm (2.5 in) deep. This box will accommodate one or two metric designator 21 (trade size ¾) conduits. Where a larger conduit is required, the box size shall be increased accordingly. Specialty boxes may be used in place of the above as appropriate. Supports for attaching the outlet box and a suitable cover plate shall be provided.

6.7.6 Low-voltage mounting bracket

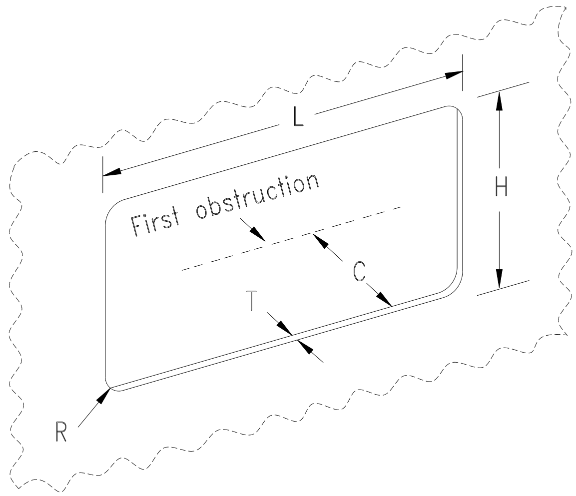
A low-voltage mounting bracket is similar to a plaster ring and may be used in place of an outlet box where permitted by code.

6.7.7 Furniture

If furniture is used in the serviced area, the equipment outlet openings provide for mounting an equipment outlet box. Two standard sizes of openings are specified:

a) NEMA-equivalent opening: This size shall provide openings that are dimensionally equivalent to standard (NEMA OS 1, WD 6) openings. In addition, a minimum depth of 30.5 mm (1.2 in) should be provided; and

b) alternative (furniture-size) opening: These openings should have dimensions as specified in figure 7.



	Dimension mm	Dimension (in)	Tolerance mm	Tolerance (in)
L	68.8	(2.71)	1.02	(0.040)
H	35.1	(1.38)	0.90	(0.035)
T	1.4	(0.055)	0.64	(0.025)
R	4.06	(0.16) max.	–	
C	30.5	(1.2) min.	–	

Figure 7 – Dimensions for furniture equipment outlet opening

6.7.8 Poke-thru devices

6.7.8.1 General

Poke-thru devices shall be listed for the purpose and approved by a national recognized testing laboratory (NRTL).

6.7.8.1.1 Types

All poke-thru devices are either single service or dual service. A single service device contains either telecommunications or power. A dual service device contains both telecommunications and power.

6.7.8.1.1.1 Flush

The flush poke-thru device is, as the name suggests, flush with the top of the finished floor. It typically consists of a stem including a fire barrier, a retaining feature to anchor the poke-thru in the concrete or steel deck, and a finish trim with a cover plate.

6.7.8.1.1.2 Pedestal (raised, tombstone, monument)

The pedestal type poke-thru device is comprised of a stem including a fire barrier, a retaining feature to anchor the poke-thru device in the concrete or steel deck, and a finish trim with a device housing. This type of poke-thru device is not flush with the top of the finished floor.

6.7.8.1.2 Design and installation requirements

The fire resistance rating of the floor shall be maintained.

The requirements of the appropriate fire resistance directory, published by an NRTL, for allowable density of poke-thru devices and minimum spacing between poke-thru devices, shall be followed.

The location and density of the poke-thru devices shall be approved by a licensed structural engineer.

Locations and sizes of installed poke-thru devices shall be documented in building records.

The manufacturer shall provide information about the allowable cross sectional area of cables for each poke-thru device.

Abandoned poke-thru holes shall be properly firestopped.

6.7.9 Patch panel system

If a rack-mounted patch panel system is used for equipment outlets, a rack or cabinet should be installed to accommodate the patch panel. See 6.3.9 for additional information on racks and cabinets.

6.7.10 Other connecting hardware

When other connecting hardware is used appropriate mounting means shall be provided.

6.8 Splice box

6.8.1 Use of splice boxes

Splice boxes are intended to be used for housing splices and may also be used for pulling cable.

Conduit fittings shall not be used in place of splice boxes.

See 9.8.2.4 for additional requirements when splice boxes are also used as pull boxes.

6.8.2 Design guidelines

Splice boxes shall be readily accessible. Splice boxes shall not be placed in a fixed false ceiling space unless immediately above a suitably marked access panel.

Splice box design should be developed in accordance with the security plan of the building.

If the splice box is comprised of metallic components, it shall be bonded to ground in accordance with the authority having jurisdiction.

Splice boxes used with conduit shall be sized per table 4.

Table 4 – Splice box sizing

Metric designator (trade size)	Width mm (in)	Length mm (in)	Depth mm (in)	Width increase for additional conduit mm (in)
27 (1)	300 (12)	810 (32)	100 (4)	75 (3)
35 (1-¼)	355 (14)	915 (36)	125 (5)	100 (4)
41 (1-½)	450 (18)	990 (39)	150 (6)	100 (4)
53 (2)	500 (20)	1065 (42)	175 (7)	125 (5)
63 (2-½)	610 (24)	1220 (48)	200 (8)	150 (6)
78 (3)	760 (30)	1375 (54)	225 (9)	150 (6)
91 (3-½)	915 (36)	1525 (60)	255 (10)	175 (7)
103 (4)	1065 (42)	1675 (66)	275 (11)	175 (7)

7 ACCESS PROVIDER SPACES AND SERVICE PROVIDER SPACES

7.1 General

Access provider spaces and service provider spaces are used for the location of transmission, reception, and support equipment. Sufficient space shall be developed for multiple access providers and service providers.

Access provider spaces and service provider spaces shall meet the requirements of 6.3 with additional requirements, exceptions and allowances as specified in clause 7.

Guidelines for access provider spaces and service provider spaces are shown in table 5 and figure 8. Access providers or service providers may have additional or different requirements for these spaces.

Table 5 – Summary of access provider spaces and service provider spaces

Space name	Minimum recommended space size	Sample functions/equipment
Access provider space	1.5 m x 2 m (4 ft x 6 ft)	Location for access provider transmission and support equipment
Service provider space	1.5 m x 2 m (4 ft x 6 ft)	Location for service provider transmission and support equipment

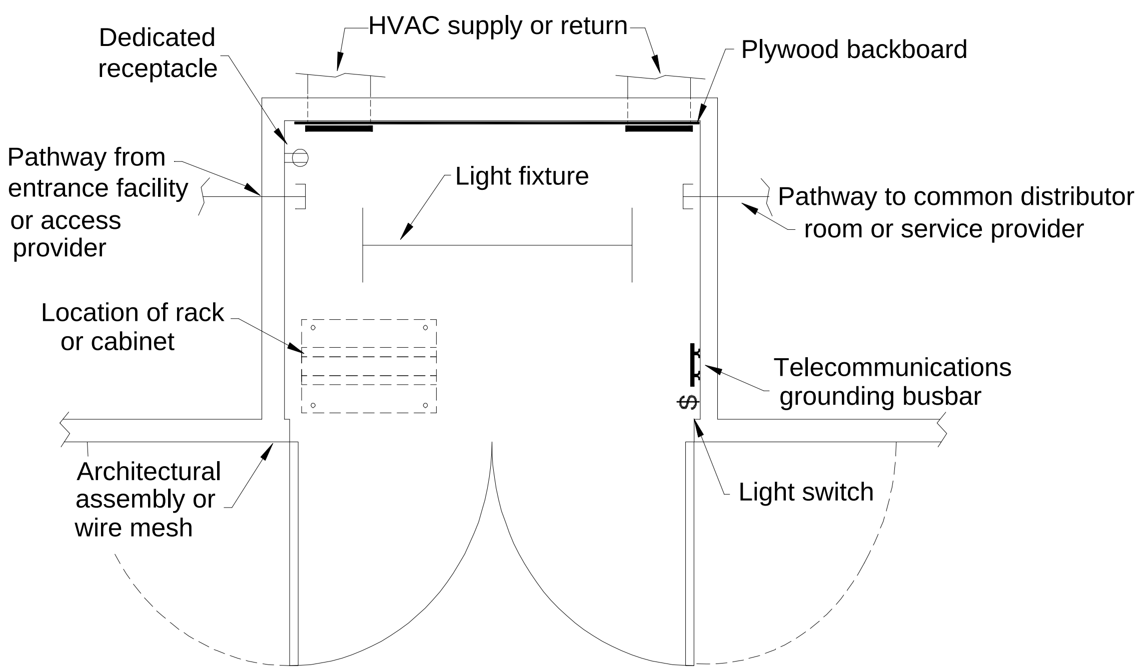


Figure 8 – Example of an access provider or service provider space

7.2 Location

Access provider spaces and service provider spaces should be in close proximity to Distributor C. The access provider and service provider spaces should be selected so that the area may be expanded. Access provider spaces and service provider spaces shall be located so that each can be accessed through common-use corridors. Wireless access provider spaces should be located as close as practicable to the wireless transmission/reception devices to which they are connected.

7.3 Pathways

Adequate cable pathway should be provided from access provider spaces to Distributor C, from service provider spaces to Distributor C, and from access provider spaces to service provider spaces.

7.4 Design

7.4.1 Architectural

7.4.1.1 Partitions

Where access providers and service providers share space, individual spaces should be segregated by means of partitions. Partitions may be comprised of wire mesh or architectural assemblies.

7.4.1.2 Signage

When wireless access provider spaces and service provider spaces are employed and wherever exposure to radio frequency electromagnetic fields may cause harm to personnel as characterized in FCC Bulletin OET 65, hazard warning signs with formats meeting standards as specified in ANSI C95.2 should be posted.

> **NOTE –** The FCC requires that certain licenses and registrations be displayed in a conspicuous location.

7.4.2 Environmental

7.4.2.1 Heating, ventilation and air conditioning (HVAC)

7.4.2.1.1 General

Access provider and service provider equipment is often designed to operate in extreme environmental conditions such as temperature. Air handling requirements should be based on potential heating and cooling demand associated with equipment that may be present in the space including, but not limited to:

a) servers;
b) data switches;
c) PBXs and key systems;
d) coaxial amplifiers;
e) video distribution equipment; and
f) uninterruptible power supplies.

7.4.2.1.2 Continuous operation

HVAC shall be provided on a 24 hours-per-day, 365 days-per-year basis. One means of providing around-the-clock HVAC is use of a stand-alone unit.

7.4.2.1.3 Standby operation

If a standby power source is available in the building, consideration should be given to also connecting the HVAC system serving the telecommunications access provider space and service provider space to the standby supply.

7.4.2.1.4 Positive pressure

A positive pressure differential with respect to surrounding areas should be provided unless prohibited by the AHJ.

7.4.2.2 Other mechanical fixtures

Mechanical (e.g., piping, ductwork, pneumatic tubing) fixtures not related to the support of the access provider space and service provider space should not be installed in, pass through, or enter the access provider space or service provider space.

7.4.3 Electrical

7.4.3.1 Power

7.4.3.1.1 General

Access provider and service provider power requirements shall be specified by the respective provider. As a minimum guideline, provide at least one dedicated 20 A, 120 Vac nominal, non-switched duplex electrical receptacle for equipment in each access provider space and service provider space. Operators of access provider spaces and service provider spaces shall be allowed access to convenience duplex receptacle(s).

7.4.3.1.2 Standby power

If a standby power source is available in the building, consideration should be given to also connecting the electrical system serving the telecommunications access provider space and service provider space to the standby supply.

7.4.3.2 Bonding and grounding

Access shall be made available to the telecommunications bonding and grounding infrastructure specified by ANSI/TIA-607-B.

8 MULTI-TENANT BUILDING SPACES

8.1 General

Common distributor rooms serve multiple tenants in a multi-tenant building (see figure 9). Pathways and spaces that are located within a multi-tenant building are described in clause 6 and clause 9.

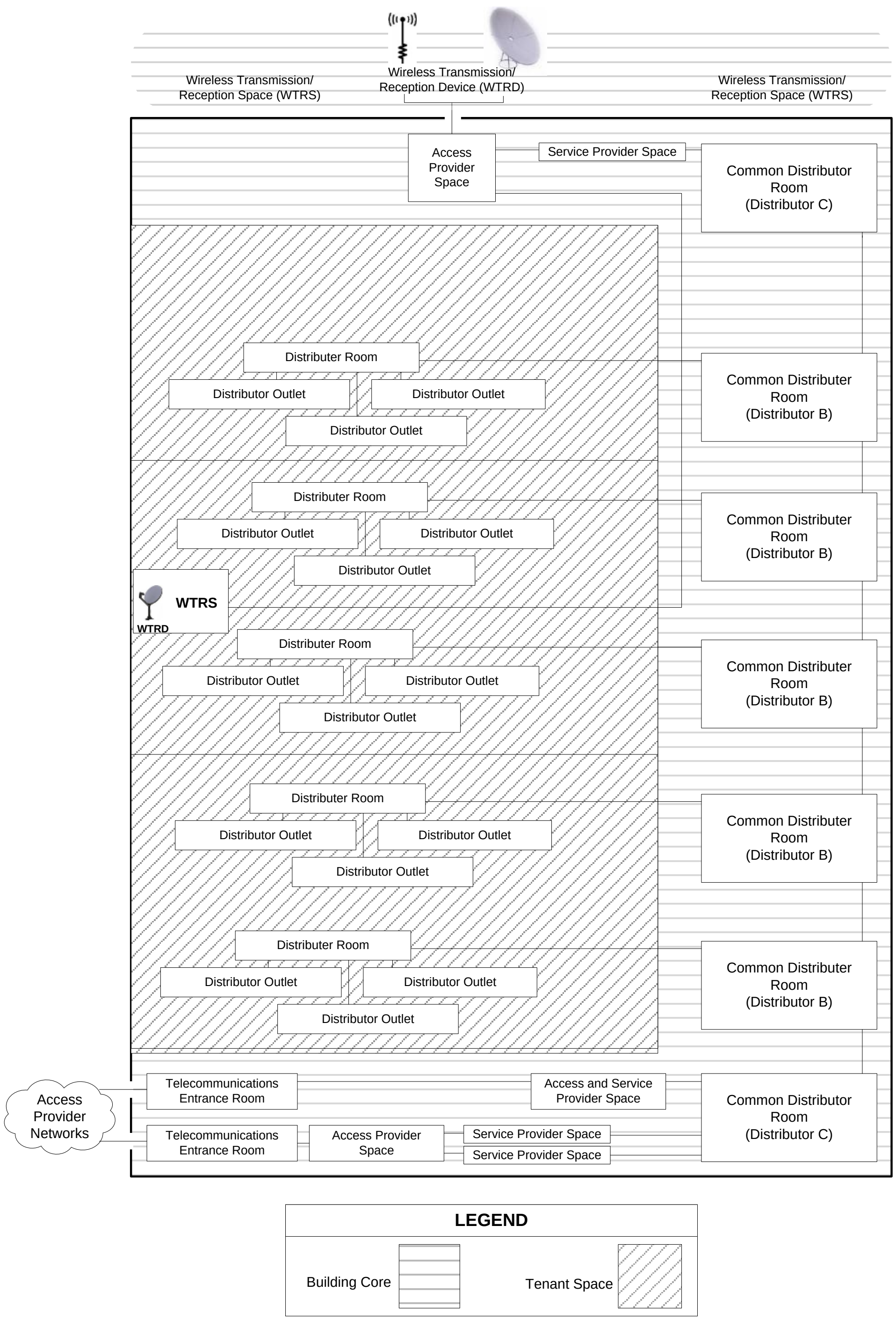


Figure 9 – Example of pathways and spaces in a multi-tenant building

8.2 Common distributor room

8.2.1 General

A common distributor room should contain only those facilities that serve multiple tenants in a building. Tenant customer premises equipment shall not be located in a common distributor room.

The common distributor room shall meet the requirements of 6.3 with additional requirements, exceptions and allowances as specified in 8.2. Figure 10 shows an example of a common distributor room.

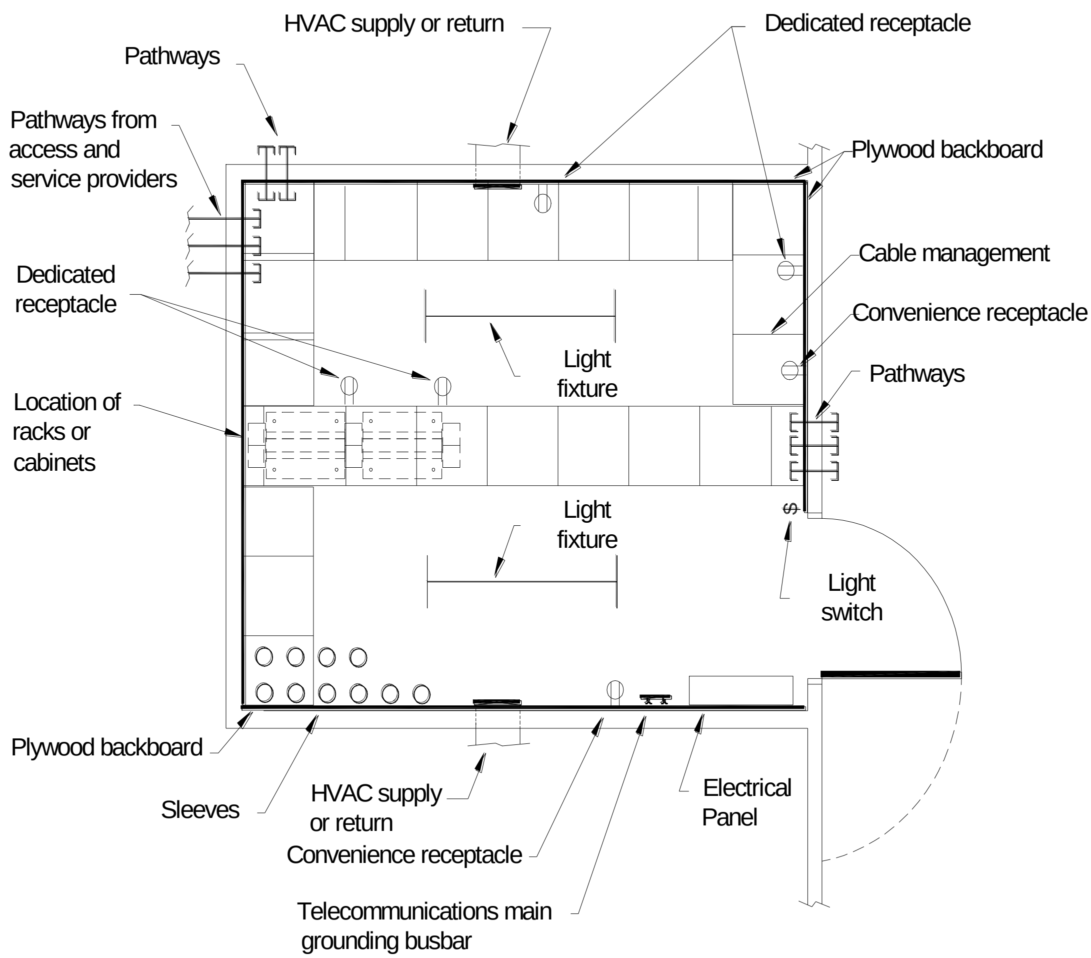


Figure 10 – Example of a common distributor room

8.2.2 Location

Whenever practicable, common distributor rooms in multi-story buildings should be vertically aligned. The common distributor room should be located central to the area served and accessible through common-use corridors.

8.2.3 Number and size of penetrations

Designers should take into consideration the following requirements when developing the quantity and size of common distributor room penetrations:

a) cable infrastructures shared by multiple tenants;
b) intra-building connectivity requirements;
c) inter-building connectivity requirements;
d) wireline access/service providers' bypass needs; and
e) wireless access/service providers' bypass needs.

In the event that cable infrastructures shared by multiple tenants do not meet specific tenant needs, sufficient pathway capacity should be set aside to accommodate bypass of shared infrastructures (see 8.2.5).

8.2.4 Design

8.2.4.1 Architectural

8.2.4.1.1 General

The design of the common distributor room shall be based upon the present and future requirements of the space to be served.

8.2.4.1.2 Size

Common distributor rooms shall be sized per 6.4.4.1.1.

8.2.4.1.3 Quantity

When the area served exceeds 2000 m^2 (20 000 ft^2) consideration should be given to providing more than one common distributor room.

8.2.4.2 Environmental

8.2.4.2.1 Standby operation

If a standby power source is available in the building, the HVAC system serving the common distributor room should be connected to the standby supply.

8.2.4.2.2 Positive pressure

A positive pressure shall be maintained unless prohibited by the AHJ.

8.2.4.3 Electrical

8.2.4.3.1 Power

8.2.4.3.1.1 General

A common distributor shall be equipped with a minimum of two 20 A, 120 Vac nominal, non-switched duplex electrical convenience receptacles and two dedicated 20 A, 120 Vac nominal, non-switched duplex electrical receptacles for equipment power. Convenience duplex outlets should be placed at 1.8 m (6 ft) intervals around the perimeter walls, at a height of 150 mm (6 in) above the floor.

> **NOTE –** It may be desirable to install dedicated feed-through power panels to serve groupings of vertically-aligned common distributor rooms.

8.2.4.3.1.2 Standby power

If a standby power source is available in the building, consideration should also be given to connecting the electrical system serving the common distributor room to the standby supply.

8.2.4.3.2 Bonding and grounding

A bonding and grounding system as specified by ANSI/TIA-607-B shall be provided.

8.2.5 Common pathways and spaces bypass

Common pathways and spaces bypass occurs when the tenant's requirements exceed the common use pathways or spaces of a building. An example of this bypass is when a tenant wants to keep their cabling physically separate from the common pathways and spaces used by other tenants in the multi-tenant building. Bypass results in a capacity reduction of the building's common pathways and spaces. Common pathways and spaces bypass may be implemented using the specifications in clause 9. As the quantity of bypassing tenants increases, so do the building's pathways and spaces decrease. Without careful management, tenant bypass can effectively exhaust a multi-tenant building's fixed and limited pathways and spaces.

8.2.6 Campus pathways

Campus pathways for multi-tenant buildings in a campus environment shall meet the requirements of ANSI/TIA-758-B.

9 BUILDING PATHWAYS

9.1 General

When determining the size of the pathway, the quantity, size, and bend radius requirements of the cable, with an allowance for growth, shall be provided. Where a large number of cables are expected, additional sleeves, conduits, trays, or slots shall be provided.

Pathways shall not be located in elevator shafts.

Pathway specifications shall accommodate the applicable seismic zone requirements.

Building pathways shall be installed in "dry" locations that protect cables from moisture levels that are beyond the intended operating range of "inside" premises cable (see ANSI/TIA-568-C.0). For example, "slab-on-grade" designs wherein pathways are installed underground or in concrete slabs that are in direct contact with earth are considered to be "wet" locations. See NFPA 70 for definitions of damp, dry and wet locations.

The integrity of all firestop assemblies shall be maintained when penetrated by cable, wires, and pathways (see Annex A).

Building pathways shall terminate in the distributor rooms or distributor enclosures located on the same floor as the area being served. Distributor rooms shall be connected to the building pathway for cabling to the entrance room or space, and the telecommunications rooms. The size of pathways, between the entrance point and the entrance room or space, shall be the same as the entrance pathways unless the route is through open accessible areas. In such cases, the pathway placed may be only for those cables initially installed with supporting structure adequate to accommodate future pathway requirements.

9.2 Types of building pathways

Areas above ceilings may be used as pathways for telecommunications cables as well as spaces for connecting hardware.

Access floor systems consist of modular floor panels supported by pedestals, an assembly of pedestals and stringers, or an integral pedestal and floor panel. Access floor systems are typically used in distributor rooms.

Cable support systems discussed here may be located below or above the ceiling or within an access floor system in either plenum or non-plenum applications. Cable trays and cable runways are structures with pre-fabricated components for supporting and routing cables or conductors that are pulled or laid in place after the pathway has been installed as a complete system.

Underfloor duct systems are pathways for containing cables for services such as telecommunications and electrical power. The system, consisting of distribution and feeder ducts, is a network of raceways embedded in concrete.

A cellular floor is an in-floor system generally used in steel frame buildings in floors located above grade. The pre-manufactured steel or concrete cellular floor sections act as the concrete form and later, in combination with perpendicular header ducts, act as the distribution raceways.

Inserts provide access to underfloor distribution ducts and distribution cells. A preset insert is a device installed before the concrete pour to provide an opening into one distribution duct or cell for attachment of a floor service fitting. An afterset insert is a field-installed device that provides an opening into one distribution duct or cell, after the concrete has been poured, for attachment of a floor service fitting. Abandonment is the deactivation of an insert after a floor service fitting is removed.

Perimeter raceways are surface-mounted pathways, often installed at baseboard, chair-rail, or ceiling height, that may contain equipment outlets. When outlets are provided as part of a perimeter raceway system, the outlet height shall comply with the requirements of the ADA where applicable. Surface raceway systems may be used as a distribution system within and between rooms and may extend from building pathways to furniture pathways to connect furniture partitions or furniture systems.

Utility columns provide pathways for wires and cables extending from the ceiling to the service area.

9.3 Pathway separation from EMI sources

9.3.1 Separation between telecommunications and power cables

9.3.1.1 General

Co-installation of telecommunications cable and power cable is governed by applicable electrial code for safety. For minimum separation requirements of electrically conductive telecommunications cable from typical branch circuits (120/240 Vac, 20 A), the requirements of NFPA 70 shall be applied, for example:

a) separation from power conductors;
b) separation and barriers within raceways; and
c) separation within outlet boxes or compartments.

Zero pathway separation distance is permitted when the electrically conductive telecommunications cables, the power cables or both are enclosed in metallic pathways that meet the following conditions:

a) the metallic pathway(s) completely enclose the cables and are continuous;
b) the metallic pathway(s) are properly bonded and grounded per ANSI/TIA-607-B; and
c) the walls of the pathway(s) have a minimum thickness 1 mm (0.04 in) nominal if made of steel or 1.5 mm (0.06 in) nominal if made of aluminum.

No separation is required between power and telecommunications cables crossing at right angles.

9.3.1.2 Additional recommendations

Table 6 provides guidelines for separation of telecommunications pathways for balanced twisted-pair cabling from adjacent power wiring based on calculated electromagnetic coupling of 50/60 Hz power and of EFT/B pulses on the power wiring. The recommendations are based on the following assumptions:

a) power line, neutral, and grounding conductors are maintained close together (e.g., twisted, sheathed, taped, or bundled together) for minimizing inductive coupling into telecommunications cabling;
b) a 480 Vac, 3-phase (phase-to-phase) balanced circuit is considered to be equivalent to three 230 Vac, 1-phase (phase-to-neutral or ground) circuits; and
c) a 120 Vac, 1-phase (phase-to-neutral or ground) is considered to be equivalent to a 230 Vac, 1-phase (phase-to-neutral or ground) branch circuit for EMI purposes.

The recommended separation distances in table 6 may be halved if the power cables and data cables are installed in separate solid metallic or wire mesh cable trays. Solid trays may have slots for easy attachment of the cables. These slots should be small, 50 mm x 10 mm (2.0 in x 0.4 in) maxi-mum, and parallel to the axis of the tray as shown in figure 11.

NOTE – For noise frequencies to 100 MHz solid and wire mesh trays are essentially equivalent.

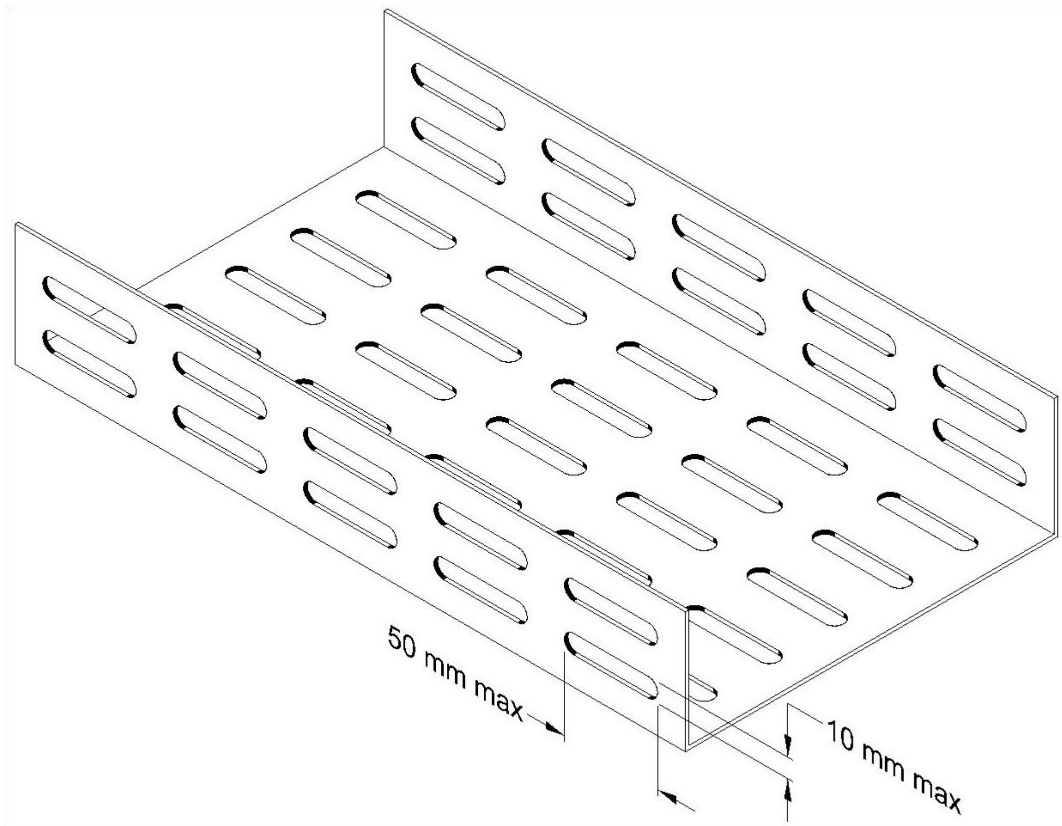


Figure 11 – Cable tray design for reduced separation

Table 6 – Recommended separation from power wiring for balanced twisted pair cabling

Power circuit type (sinusoidal 50/60 Hz)	Number of radial power circuits	Minimum recommended separation, mm (in)[1]				
		E1 (EFT/B = 500V)		E2 (EFT/B = 500 V), E3 (EFT/B = 1000 V)		
		Unscreened power cables	Armored or screened power cables[2]	Unscreened power cables		Armored or screened power cables[2]
				Unshielded cable	Shielded cable	
120/230 Vac, 20 A 1-phase	1	0 (0)	0 (0)	50 (2)	1 (0.04)[3]	0 (0)
	2	0 (0)	0 (0)	50 (2)	5 (0.2)[3]	2.5 (0.1)
	3	0 (0)	0 (0)	50 (2)	10 (0.4)[3]	5 (0.2)
	4	0 (0)	0 (0)	50 (2)	12 (0.5)[3]	6 (0.2)
	5 – 15	0 (0)[3]	0 (0)	50 (2)	50 (2)	25 (1)
	16 – 30	100 (4)	50 (2)	100 (4)	100 (4)	50 (2)
	31 – 60	200 (8)	100 (4)	200 (8)	200 (8)	100 (4)
	61 – 90	300 (12)	150 (6)	300 (12)	300 (12)	150 (6)
	≥ 91	600 (24)	300 (12)	600 (24)	600 (24)	300 (12)
120/230 Vac, 32 A 1-phase	1	10 (0.4)[3]	5 (0.2)	50 (2)	10 (0.4)[3]	5 (0.2)
	2	20 (0.8)[3]	10 (0.4)	50 (2)	20 (0.8)[3]	10 (0.4)
	3	30 (1)[3]	15 (0.6)	50 (2)	30 (1)[3]	15 (0.6)
	4 – 5	50 (2)	25 (1)	50 (2)	50 (2)	25 (1)
	6 – 9	100 (4)	50 (2)	100 (4)	100 (4)	50 (2)
	10 – 19	200 (8)	100 (4)	200 (8)	200 (8)	100 (4)
	20 – 28	300 (12)	150 (6)	300 (12)	300 (12)	150 (6)
	≥ 29	600 (24)	300 (12)	600 (24)	600 (24)	300 (12)
120/230 Vac, 63 A 1-phase	1	50 (2)	25 (1)	50 (2)	50 (2)	25 (1)
	2 – 3	100 (4)	50 (2)	100 (4)	100 (4)	50 (2)
	4 – 8	200 (8)	100 (4)	200 (8)	200 (8)	100 (4)
	9 – 14	300 (12)	150 (6)	300 (12)	300 (12)	150 (6)
	≥ 15	600 (24)	300 (12)	600 (24)	600 (24)	300 (12)
120/230 Vac, 100 A 1-phase	1	100 (4)	50 (2)	100 (4)	100 (4)	50 (2)
	2	200 (8)	100 (4)	200 (8)	200 (8)	100 (4)
	3	300 (12)	150 (6)	300 (12)	300 (12)	150 (6)
	≥ 4	600 (24)	300 (12)	600 (24)	600 (24)	300 (12)
480 Vac, 100 A 3-phase	1	300 (12)	300 (12)	300 (12)	300 (12)	300 (12)
	≥ 2	600 (24)	600 (24)	600 (24)	600 (24)	600 (24)

NOTES:

1. Separation distances may be halved if the power cables and data cables are installed in separate metallic pathways (see above).
2. Armoring or screening must completely surround the cable (except at the socket) and be properly bonded and grounded (earthed).
3. 50 mm (2 in) if loose (individual) power conductors are used and not bundled or maintained close together.

9.3.2 Telecommunications pathway separation from lighting

Balanced twisted-pair cabling should be separated from fluorescent lamps and associated fixtures by a minimum of 125 mm (5 in).

9.3.3 Reducing noise coupling

In order to further reduce noise coupling in electrically conductive telecommunications cables from sources such as electrical power wiring, radio frequency (RF) sources, large motors and generators, induction heaters, and arc welders, the following additional precautions should be considered:

a) increased physical separation;
b) electrical branch circuit line, neutral, and grounding conductors should be maintained close together (e.g., twisted, sheathed, taped, or bundled together) for minimizing inductive coupling into telecommunications cabling;
c) use of surge protectors in branch circuits that can further limit the propagation of electrical surges. Follow guidelines in ANSI/IEEE 1100; and
d) use of fully enclosed, grounded metallic raceway or grounded conduit or use of cable installed close to a grounded metallic surface that will also limit inductive noise coupling. Refer to ANSI/TIA-607-B and ANSI/IEEE 1100.

NOTE – For more information on noise reduction, see annex B.

9.4 Areas above ceilings

9.4.1 General

Inaccessible ceiling areas, such as lock-in type ceiling tiles, drywall or plaster, shall not be used as distribution pathways. Ceiling tiles shall be of the removable or lay-in type. Adequate and suitable space shall be available in the ceiling area for the contemplated layout.

9.4.2 Design guidelines

9.4.2.1 Planning

The design shall provide a suitable means and method for supporting cables. Cable shall not be laid directly on the ceiling tile or rails.

9.4.2.2 Clearance

A minimum of 75 mm (3 in) clear vertical space shall be available above the ceiling tiles for the cabling and pathway.

9.5 Access floor systems

9.5.1 General

Some access floor systems may also be used for air handling. Low profile access floor systems are not recommended for air handling.

There are two types of access floor systems: 1) standard height floors and 2) low profile floors. Each of these types can have any one or a combination of support structures including:

a) stringered systems;
b) free standing systems;
c) cornerlock systems; and
d) integral systems.

9.5.2 Loading performance

Performance information for static, dynamic and impact loading conditions are provided in CISCA *Recommended Test Procedures for Access Floors*.

9.5.3 Building structure

9.5.3.1 Depressed slab

In new construction, the area planned to receive the access floor system should be depressed to a depth equal to the height of the access floor.

9.5.3.2 Normal or partially depressed slab

Where the slab is not depressed, or where the depth of the depression is not equal to the height of the finished access floor, provision shall be made for ramps or steps to the access floor in accordance with ADA requirements. Building codes shall be followed for both ramp and step assemblies.

9.5.4 Design guidelines

9.5.4.1 Service area service fittings

Service area service fittings shall be designed into the floor plan to accommodate the number and location of service areas planned, and the type of service fitting to be used. Service fittings shall not be placed in traffic areas or where they create a hazard to the occupants.

9.5.4.2 Minimum clearance

Minimum clearance in cable pathways under an access floor shall be 20 mm (0.75 in) (see figure 12). A minimum of 650 mm^2 (1 in^2) cross sectional area shall be provided per service area.

When used in a distributor room, the minimum finished floor height should be 300 mm (12 in) above the slab and shall not be less than 150 mm (6 in) above the slab.

> **NOTE –** Where cable tray or other facilities are used under other areas, a minimum of 200 mm (8 in) above the slab should be considered.

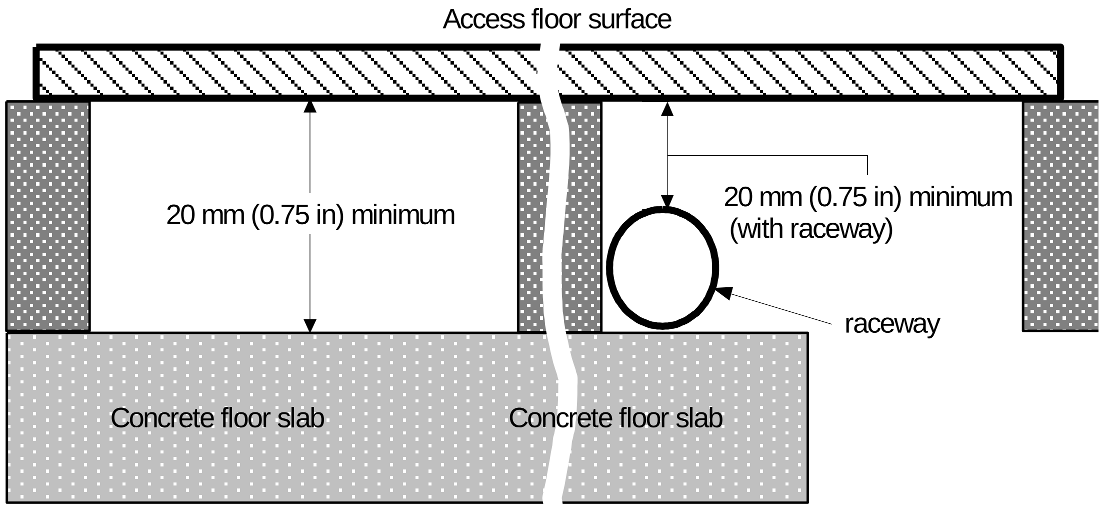


Figure 12 – Access floor system minimum clearances

9.5.4.3 Cable management

Providing physical management for cabling placed within the access floor system lessens the chance of damage or reduced performance over the cable's life cycle. A method of physical management for major runs of cabling shall be provided. Management systems such as raceways, cable tray, and non-continuous cable supports may be used.

9.5.5 Installation

9.5.5.1 Layout

The access floor system layout shall be determined prior to the installation of any equipment or telecommunications cabling.

9.5.5.2 Linkage to distributor room or distributor enclosure

Access floor system areas should be adjacent to distributor rooms or distributor enclosures. If not adjacent, other means of linkage shall be provided. Sizing of the interconnecting pathways shall be based on the design criteria for that specific type of pathway.

9.6 Cable tray and cable runway

9.6.1 General design information and cable fill

9.6.1.1 Cable trays

Cable trays shall be planned for an initial maximum calculated fill ratio of 25% (see example 1). The maximum fill ratio of any cable tray shall be 50%. The maximum fill depth of any cable tray shall be 150 mm (6 in).

> **NOTE –** A calculated fill ratio of 50% for four-pair and similar diameter cables will physically fill the entire tray due to spaces between cables, and random placement. See figure 13.

.

Figure 13 – Cable tray with 5.5 mm (0.22 in) diameter cables at 50% calculated fill

NOTE – This photo does not constitute an endorsement by TIA or this Committee of the product in the image, when suitable, alternative products or technologies may be substituted.

Example 1 – What is the minimum width of a 75 mm (3 in) deep cable tray supporting 500 cables, each with a diameter of 5.5 mm (0.22 in)?

$$Area\,of\,one\,cable = \frac{\pi \times (cable\ diameter)^2}{4} \tag{1}$$

$$Area\,of\,500\,cables = 500 \times \frac{3.14 \times 5.5^2}{4} = 11\,873\ \text{mm}^2 \tag{2}$$

$$Usable\ area\,of\ tray\,(25\%\,fill) = 0.25 \times width \times depth \tag{3}$$

$$11\,873\ mm^2 = 0.25 \times width \times 75 \tag{4}$$

$$Minimum\ width\ of\ tray = 633\,\text{mm} \tag{5}$$

NOTE – Check widths and depths available from manufacturers

Example 2 – What is the maximum number of 9.0 mm (.354 in) cables that can be placed in a 300 mm (12 in) wide by 50 mm (2 in) deep cable tray?

$$Usable\,area\,of\ tray\ (50\%\,fill) = 0.5 \times width \times depth = 0.5 \times 300 * 50 = 7500\,\text{mm}^2 \tag{6}$$

$$Area\,of\ one\,cable = \frac{\pi \times (cable\ diameter)^2}{4} = \frac{3.14 \times 9.0^2}{4} = 64\ \text{mm} \tag{7}$$

$$Maximum\ number\,of\ cables = \frac{usable\,area\,of\ cable\,tray}{area\,of\ one\,cable} = \frac{7500}{64} = 117 \tag{8}$$

9.6.1.2 Cable runway

Cables installed on cable runway shall be stacked no higher than 150 mm (6 in). Retaining posts may be installed on runway to contain cables.

9.6.2 Support

The span for cable support systems should be determined in accordance with the manufacturer's maximum recommended load capacity for a given span. These systems may be supported by three basic methods: cantilever brackets from a wall; trapeze or individual rod supports from above; or from below. Cable tray supports should be located where practicable so that connections between sections of the tray fall between the support point and one-quarter the distance of the span. A support should be placed within 600 mm (24 in) on each side of any connection to a bend, tee, or cross.

> **NOTE –** NEMA VE2 contains useful information regarding additional cable tray support and installation.

9.6.3 Installation

9.6.3.1 General

The inside of the cable support system shall be free of burrs, sharp edges or projections that can damage cable insulation. Abrasive supports (e.g., threaded rod) installed within the cable fill area shall have that portion within the tray protected with a smooth, non-scratching covering so that cable can be pulled without physical damage. Installation of telecommunications cables shall not exceed the fill requirements stated in 9.6.1. Openings in fire-rated walls, floors and ceilings shall be properly fire stopped (see Annex A). Cable trays and cable runways shall not be used as walkways or ladders.

Trays may be divided with a barrier to allow for physical separation between power and conductive telecommunications cables. Power and telecommunications cables shall be installed per electrical code. A minimum of 300 mm (12 in) access headroom shall be provided and maintained above a cable tray system or cable runway. Care shall be taken to ensure that other building components (e.g., air conditioning ducts) do not restrict access.

9.6.3.2 Pathway termination

Cable trays and cable runways within the ceiling shall protrude into the room 25-75 mm (1-3 in), without a bend, and above the 2.4 m (8 ft) level. These pathway entry requirements prevent partial bend transitions through the wall and ensure that the cable is at a height that may be fed to termination fields without interfering with equipment racks or back panels.

9.7 Non-continuous support

Non-continuous supports shall be located at intervals not to exceed 1.5 m (5 ft). Non continuous supports shall be selected to accommodate the immediate and anticipated quantity, weight, and performance requirements of cables.

Steel, masonry, independent rods, independent support wires or other structural parts of the building shall be used for cable support attachment points up to the total weight for which the fastener is approved. Rods or wires that are currently employed for other functions (e.g. suspended ceiling grid support) shall not be utilized as attachment points for non-continuous supports.

> **NOTE –** A weight of 1 kg (2.2 lb) (or 0.7 kg/m (0.5 lb/ft) with spacing of support wire/rod at 1.5 m (5 ft)) is equivalent to a bundle of sixteen 4-pair 24 AWG UTP cables, including fasteners.

9.8 Conduit

9.8.1 Use of conduit

The use of conduit as a horizontal raceway system for telecommunications cabling is considered when: it is required by code, outlet locations are permanent, device densities are low, special mechanical protection is required, or flexibility is not required. In-floor conduit systems are especially inflexible as they are usually buried in concrete.

The use of flexible metal conduit is not recommended. If flexible metal conduit is used, the length should be less than 6 m (20 ft) for each run and the conduit selected should minimize cable abrasion during the pulling in operation.

Other products including innerduct (also known as subduct) are typically nonmetallic pathways within a pathway, and may be used in accordance with appropriate codes for installation of cable to facilitate subsequent placement of additional cable in a single pathway.

9.8.2 Design guidelines

9.8.2.1 Length

No section of conduit shall be longer than 30 m (100 ft) between pull points.

9.8.2.2 Bends

No section of conduit shall contain more than two 90 degree bends, or equivalent, between pull points (e.g., outlet boxes, pull boxes, distributor rooms). If there is a reverse (U shaped) bend in the section, a pull box shall be installed.

For conduits with an internal diameter of 50 mm (2 in) or less, the inside radius of a bend in conduit shall be at least 6 times the internal diameter. For conduits with an internal diameter of more than 50 mm (2 in), the inside radius of a bend in conduit shall be at least 10 times the internal diameter. Bends in the conduit shall not contain any kinks or other discontinuities that may have a detrimental effect on the cable sheath during cable pulling operations.

9.8.2.3 Pull tension

The pull tension of the cable being installed shall not be exceeded. Some factors that determine pull tension of cable include:

a) conduit size;
b) length of conduit;
c) location and severity of bends;
d) cable jacket material;
e) cable weight;
f) number of cables;
g) conduit material;
h) lubricants;
i) direction of pull; and
j) firestopping.

Conduit sizing is directly related to the planned diameter of the cable and the maximum pull tension that can be applied to the cable without degradation of the cable transmission properties.

The pull tension limit is based on the strength of the conduit (including sidewall pressure), the tensile strength of the pull line, the geometry of the conduit system, and the tensile strength of the cable. The position of the bends and length of the conduit system will affect the pull tension that will be imposed on a cable. For instance, pulling cable in one direction may cause a cable pull tension of 2700 N (600 lbf) whereas pulling from the opposite direction may cause a tension of 1350 N (300 lbf).

> **NOTE –** Cable pulling tensions may be reduced by using lubricants. Care should be practiced in lubricant selection, taking into consideration compatibility with cable jacket composition, safety, lubricity, adherence, stability and drying speed.

9.8.2.4 Pull boxes

9.8.2.4.1 Use of pull boxes

Pull boxes shall be used for the following purposes:

a) fishing the conduit run;
b) installing a pull string or cable; and
c) pulling the cable to the box and then looping the cable to be pulled into the next length of conduit. This is usually done with smaller diameter cables and not with cables of 64 mm (2 ½ in) diameter or greater.

See 6.7.9 for additional requirements when pull boxes are also used as splice boxes.

Conduit fittings shall not be used in place of pull boxes.

9.8.2.4.2 Design guidelines

Pull boxes shall be readily accessible. Pull boxes shall not be placed in a fixed false ceiling space unless immediately above a suitably marked access panel.

A pull box shall be placed in a conduit run where:

a) the length is over 30 m (100 ft);
b) there are more than two 90º bends, or equivalent; or
c) there is a reverse (U-shaped) bend in the run.

Pull boxes should be placed in a straight section of conduit and shall not be used in lieu of a bend. The corresponding conduit ends should be aligned with each other.

Where a pull box is required with conduits smaller than metric designator 35 (trade size 1¼), an outlet box may be used as a pull box. Where a pull box is used with conduits, it shall be sized per table 7.

If the pull box is comprised of metallic components, it shall be bonded to ground in accordance with the authority having jurisdiction.

Table 7 – Pull box sizing

Metric designator (trade size)	Width mm (in)	Length mm (in)	Depth mm (in)	Width increase for additional conduit mm (in)
27 (1)	102 (4)	406 (16)	76 (3)	51 (2)
35 (1-¼)	152 (6)	508 (20)	76 (3)	76 (3)
41 (1-½)	203 (8)	686 (27)	102 (4)	102 (4)
53 (2)	203 (8)	914 (36)	102 (4)	127 (5)
63 (2-½)	254 (10)	1067 (42)	127 (5)	152 (6)
78 (3)	305 (12)	1219 (48)	127 (5)	152 (6)
91 (3-½)	305 (12)	1372 (54)	152 (6)	152 (6)
103 (4)	381 (15)	1524 (60)	203 (8)	203 (8)

9.8.2.5 Conduit runs to outlets

Any single conduit run extending from a distributor room shall not serve more than three equipment outlet boxes.

Conduits should be incrementally increased in size from the furthest outlet box toward the telecommunications room.

9.8.2.6 Pathway termination

Conduits protruding through the floor in the distributor room shall be terminated 25-75 mm (1-3 in) above the floor surface. This protrusion aids in preventing poured concrete from entering the conduit during construction and protects cabling and firestop materials from water and other liquid spills.

Conduits within the ceiling shall protrude into the room from 25-75 mm (1-3 in), without a bend, and above the 2.4 m (8 ft) level. These pathway entry requirements prevent partial bend transitions through the wall and ensure that the cable is at a height that may be fed to connecting hardware without interfering with equipment racks or back panels.

9.8.2.7 Conduit to wall-mounted public telephone locations

A minimum metric designator 21 (trade size ¾) conduit should be provided from the telecommunications room to serve each wall-mounted public telephone. In discussion with the telephone provider, and where it is desirable to conceal the outlet box directly behind the surface-mounted telephone, the center of the outlet box shall be placed 1.2 m (4 ft) above the floor.

9.8.2.8 Elevator telecommunications

A minimum metric designator 21 (trade size ¾) conduit shall be provided from the telecommunications room to a suitable device box. This location shall apply to passenger, freight, and window-washing elevators and be coordinated with the elevator contractor.

9.8.2.9 Conduit to outdoor locations

Where a telecommunications conduit is to be placed to a device exposed to the weather, care shall be taken to prevent the ingress of moisture. Care shall also be taken to ensure that moisture will not collect in low points, which may freeze and damage the cable. Nonmetallic conduit shall be UV resistant and marked accordingly.

9.8.3 Installation

9.8.3.1 Conduit termination

Conduits shall be reamed to eliminate sharp edges. Metallic conduit shall be terminated with an insulated bushing.

9.8.3.2 Pull strings

Pull string or rope shall be placed in installed conduits.

9.9 Furniture

9.9.1 Building interfaces

The interface between building walls, columns, ceilings and floors and furniture should conceal and protect the cable, while allowing unobstructed access to junction boxes or pathways. Pathways used to interconnect the furniture with building pathways shall be provided with a cross-sectional area at least equal to the building pathway's cross-sectional area for the floor area being served.

9.9.2 Floors

Alignment of furniture with building modules, duct locations and other cable delivery means should be considered as part of the layout planning. Furniture shall not be arranged such that pathway interfaces are in aisle spaces, where people walk or place their feet, or other places where such obstructions could create a hazard.

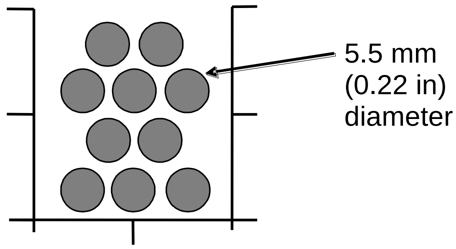
9.9.3 Ceilings

Furniture pathways that are served from the ceiling shall meet the requirements of 9.4.

9.9.4 Pathway fill factor

Pathway percent fill is calculated by dividing the sum of the cross-sectional area of all cables by the most restricted cross-sectional area of the pathway. For furniture pathways, the maximum pathway fill shall be 40% (see figure 14).

This maximum limit may be impacted by variables such as cable helix, pathway intersections, cable bending radii, and space for outlets/connectors. Actual cable installation on furniture mockups is the preferred method to determine pathway cable capacity.



NOTE – Cable capacity guidelines take into consideration that there is unusable space between cables and that cables may take independent paths. The diagram shows 5.5 mm (0.22 in) diameter cables in a 645 mm^2 (1 in^2) pathway.

Figure 14 – Furniture pathway fill

9.9.5 Furniture pathway capacity

Furniture used for telecommunications cabling shall provide a minimum (straight) pathway cross-sectional area of 950 mm^2 (1.5 in^2). This cross-sectional area is for typical cable dimensions and a pathway fill of 33%. In general, furniture pathways at any elevation above the floor may need to be fed from either the floor or the ceiling. Therefore, vertical pathways should be provided with a cross-sectional area at least equal to the building pathway cross-sectional area. This specification is based on a service area cluster serving four persons with three connections each.

Because of complex raceway shapes and obstructions, cable installation in furniture pathways by fish-and-pull techniques may result in reduced capacity compared to placing cable into the pathways. Fish-and-pull installation should not be used except when required by furniture pathway characteristics, such as a raceway with a non-removable cover.

9.9.6 Access

Furniture should be arranged to ensure that access to telecommunications pathways is not blocked. For example, wall and panel systems may be chosen with a lay-in cable pathway at the top to make access convenient.

9.9.7 Furniture pathway bend radius

The conduit bend radius rules (see 9.8.2.2) shall apply to any inaccessible furniture pathway corner where pulling forces are expected to be used to install cable.

The furniture pathway shall not force the cable into a bend radius that is less than the greater of:

a) the minimum bend radius requirement of ANSI/TIA-568-C.0;
b) the manufacturer’s recommended minimum bend radius; or
c) 25 mm (1 in).

Hybrid cables may require a larger bend radius than traditional cables. Hybrid cables are usually designed so that they may be unsheathed into component cables at the entry point to furniture, if necessary, to make the bend radius manageable. The designer should contact the cable manufacturer for minimum bending radii.

9.9.8 Reducing pathway capacity at corners

The usable cross-section of some furniture pathways is reduced by the bend radius requirements of the cable. Furniture manufacturers shall provide information on the usable cross-section or cable capacity at pathway intersections for representative cables.

9.9.9 Power/telecommunications separation

Furniture pathways often run parallel to power raceways; floor and ceiling interfaces are often divided into power and telecommunications. In such cases, separation shall be provided to meet the requirements of 9.3.

In multi-channel metallic pathways, dividers between channels shall be bonded to ground.

9.10 In-floor

9.10.1 Underfloor duct systems

9.10.1.1 General

Single-level or two level underfloor duct systems consist of either single-channel or multi-channel raceways. Single-channel ducts may be of various sizes and shall be separated by 25 mm (1 in) of concrete while multi-channel raceways shall be separated by partitions. See figure 15.

Junction boxes, access units, header ducts or trenchducts permit changes in direction and provide access for pulling cables.

Header duct and trenchduct are used as the feeder duct for single or multi-channel raceway systems.

Preset or afterset inserts are provided on the distribution raceways to provide cable egress to the service area.

All openings where cables are pulled shall be grommeted. Flush duct raceways shall not be over 103 mm (4 in) in width and shall be covered with linoleum that is not less than 3.1 mm (0.125 in) in thickness or with equivalent floor covering.

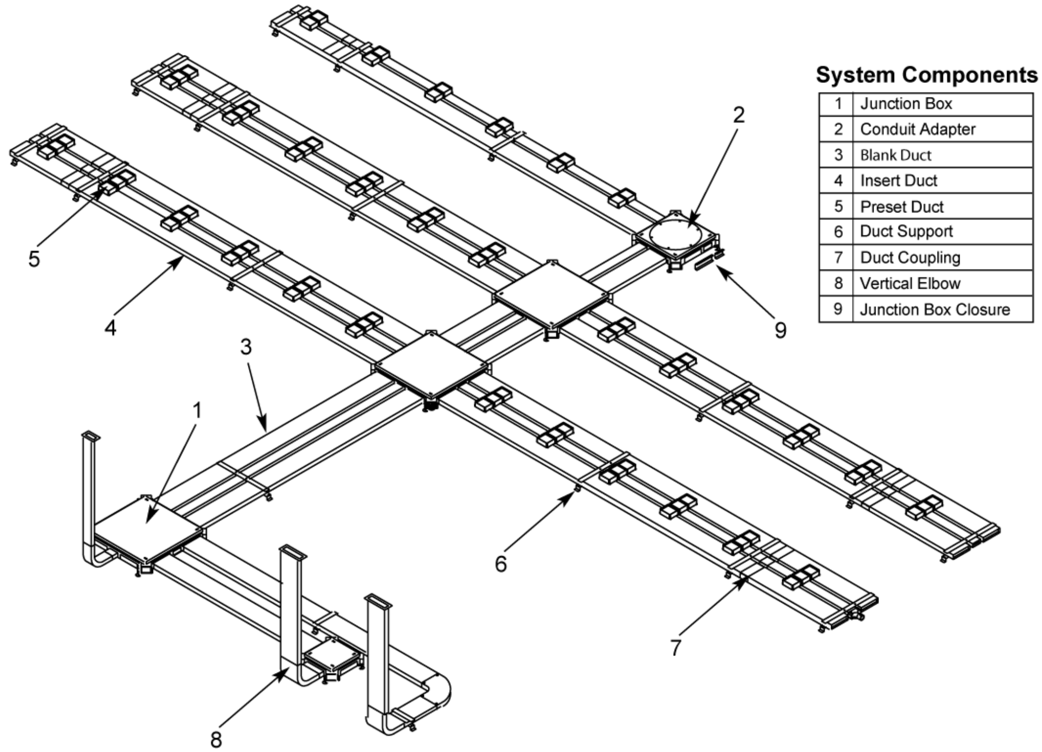


Figure 15 – Underfloor duct layout

9.10.1.2 Floor structure design

The floor structure affects the type of underfloor duct system that can be accommodated within the floor. The total depth of concrete and method of pour will dictate the selection of the duct system:

a) In a monolithic pour, the mid-point of the duct system is typically located at the mid-point of the slab. The top of the duct system shall be located at a minimum of 25 mm (1 in) below the top surface of the slab;

b) To maintain the elevation of the underfloor duct system within the slab, the under-floor duct shall be anchored to the supporting surface below;

c) In a double-pour floor, the underfloor duct system is installed on the structural slab. The second pour contains the duct system;

d) In a post-tensioned concrete pour, the underfloor duct system shall be located to avoid interference with the placement of the post-tension cables. Preset inserts shall be used; and

e) When precast concrete members are utilized, the underfloor duct system is embedded within the concrete topping. The top of the duct system shall be located at a minimum of 25 mm (1 in) below the top surface of the concrete topping while allowing for camber and unevenness in the surface of prefabricated concrete members.

9.10.1.3 Design guidelines and procedures

9.10.1.3.1 System capacities

9.10.1.3.1.1 General requirements

To determine duct requirements for general office space, based on the assumption of three devices per service area and one service area per 10 m^2 (100 ft^2), provide a minimum of 650 mm^2 (1 in^2) of cross sectional underfloor duct area per 10 m^2 (100 ft^2) of usable floor space. This practice applies to capacities of both feeder and distribution duct. Where it is known that the number of devices per service area is greater, or the service area allocation density is greater than this rule, the sizing shall be increased accordingly. Any restrictions and reductions of duct capacity at intersections and turns shall be included in the duct capacity calculation.

9.10.1.3.1.2 Specific calculation method

Another method to determine capacity requirements involves four factors that affect raceway sizes:

a) area being served;
b) quantity of service areas in that area;
c) size and quantity of cables; and
d) potential changes to service locations.

The following is a sample calculation for distribution duct capacity assuming duct center-to-center spacing of 1.6 m (5 ft), duct length of 24 m (80 ft), service areas of 6 m^2 (60 ft^2), a requirement of 3 cables per service area, cable diameter of 5.5 mm (0.22 in) and an allowance for 3 successive installations without removal of cables:

$$Area\ served = duct\ spacing \times duct\ length = 1.6 \times 24 = 38\,\mathrm{m}^2 \tag{9}$$

$$Number of\ service\ areas = \frac{area\ served}{serice\ area\ size} = \frac{38}{6} = 6 \tag{10}$$

$$Maximum\ cables = service\ areas \times cables\ per\ service\ area \times installations \tag{11}$$

$$Maximum\ cables = 6 \times 3 \times 3 = 54 \tag{12}$$

$$Area\ of\ 54\ cables = \frac{54 \times \pi \times cable\ diameter^2}{4} = \frac{34 \times 3.14 \times 5.5^2}{4} = 1282\,\mathrm{mm}^2 \tag{13}$$

$$Minimum\ duct\ size (40\%\ fill) = \frac{area\ of\ 54\ cables}{0.4} = \frac{1282}{0.4} = 3205\,\mathrm{mm}^2 \tag{14}$$

Feeder duct calculations are similar and extremely important to the design of the system. The following is a sample calculation for the feeder duct capacity assuming a total area served of 1000 m^2 (10 000 ft^2), service areas of 10 m^2 (100 ft^2), a requirement of 3 cables per service area, cable diameter of 5.5 mm (0.22 in) and an allowance for 3 successive installations without removal of cables:

$$Number of\ service\ areas = \frac{area\ served}{serice\ area\ size} = \frac{1000}{10} = 100 \tag{15}$$

$$Maximum\ cables = service\ areas \times cables\,per\ service\,area \times installations \quad (16)$$

$$Maximum\ cables = 100 \times 3 \times 3 = 900 \quad (17)$$

$$Area\,of\ 900\,cables = \frac{900 \times \pi \times cable\,diameter^2}{4}$$

$$= \frac{900 \times 3.14 \times 5.5^2}{4} = 21\ 372\,\text{mm}^2 \quad (18)$$

$$Minimum\ duct\,size(40\%\ fill) = \frac{area\,of\ 900\,cables}{0.4} = \frac{21\ 372}{0.4} = 53\ 430\,\text{mm}^2 \quad (19)$$

9.10.1.3.2 Design and layout information

In office buildings, duct runs shall be planned by locating the distribution 1520-1825 mm (5-6 ft) on center. This spacing provides good coverage and flexibility for service area placement. The runs adjacent to exterior building walls shall be located 450-600 mm (18-24 in) from the walls or column lines. After the parallel distribution runs have been established, the cross runs of feeder duct are determined by the density of the service requirements and the area to be supplied from each distributor room.

Cross runs of feeder duct may consist of:

a) blank underfloor duct with junction boxes;
b) single or multi-channel enclosed header duct with access units; or
c) single or multi-channel trench duct.

For ease of cable pulling, spacing of feeder duct, consisting of “a” or “b” above, shall not exceed 18 m (60 ft). Spacing for single or multi-channel trench duct should not exceed 30 m (100 ft).

Underfloor duct systems shall be connected to a distributor room.

The layout shall allow for the egress of cabling to the service area or furniture cluster with appropriate access and protection for the cabling.

9.10.1.4 Feeder duct

9.10.1.4.1 General

Telecommunications feeder ducts (embedded or header) shall terminate in the telecommunications room with a slot or elbow as applicable.

9.10.1.4.2 Trench duct or trench header

Trench duct shall have removable cover plates through its entire length to allow cables to be placed rather than pulled in. In a single-level system access from the trench duct to the distribution duct shall be provided through the side of the trench duct. A two-level system uses a trench header and provides access to the distribution ducts through the bottom of the trench duct. The cover plates shall have means for leveling to the intended finished floor surface and shall be fitted with a gasket to deter entry of water.

9.10.1.4.3 Supplementary feeder

Provide supplementary feeders where the embedded ducts approach distributor rooms from directions requiring horizontal bends into the space, a trench duct should be installed. The trench duct shall extend out from the telecommunications room far enough to connect all embedded ducts. If embedded ducts are used for feeder ducts, then tees or horizontal elbow fittings shall have access openings and partitions for complete separation of services.

9.10.1.5 Access unit or junction boxes

In multi-channel raceway systems, the interior of the access unit or junction box shall be partitioned to provide complete separation of services. The cover plate shall have a means of leveling it to the surrounding floor area and shall be fitted with a gasket to deter entry of water.

9.10.1.6 Installation

9.10.1.6.1 Single-level or two-level underfloor duct systems

Duct runs with preset inserts shall be leveled so that the top of the insert will be 3 mm to 9 mm (0.125 in to 0.375 in) below the finished concrete floor. Marker screws identifying the duct runs shall be placed at or near each end of the duct run. These markers, which are used to locate the duct runs after the concrete floor has been poured, shall extend through the floor surface. Ducts shall be secured to the sub slab by duct supports or hold-down straps. Junction boxes or access units shall be set to concrete screed level prior to the concrete pour. After the concrete is set, access units or junction box covers shall be leveled to the surrounding floor.

9.10.1.6.2 Trench duct or trench header

Trench duct sections shall be coupled and leveled so that the cover plates will be flush with the surface of the concrete floor. Openings from the base of the trench to the appropriate distribution duct shall be cut, and grommets shall be installed. All openings that may allow concrete to enter the raceway shall be sealed with tape prior to concrete pour. Adjustable partitions shall be raised to the underside of the cover plate and welded or bolted in place to add support to the cover and assure complete separation of services. Welds shall be painted to prevent rusting. Floor finish trim may be installed along the edge of the cover plates.

9.10.1.7 Inserts for underfloor duct systems

9.10.1.7.1 Preset inserts

Preset inserts are typically located 600 mm (24 in) on center and shall be installed before the concrete is poured.

9.10.1.7.2 Afterset inserts

Afterset inserts may be installed either before or after the concrete is poured.

9.10.1.8 Service fittings

Service fittings may provide access to one or more services. If electrical power is one of the services, the fitting shall be fully partitioned.

9.10.1.9 Floor boxes for single and multiple services

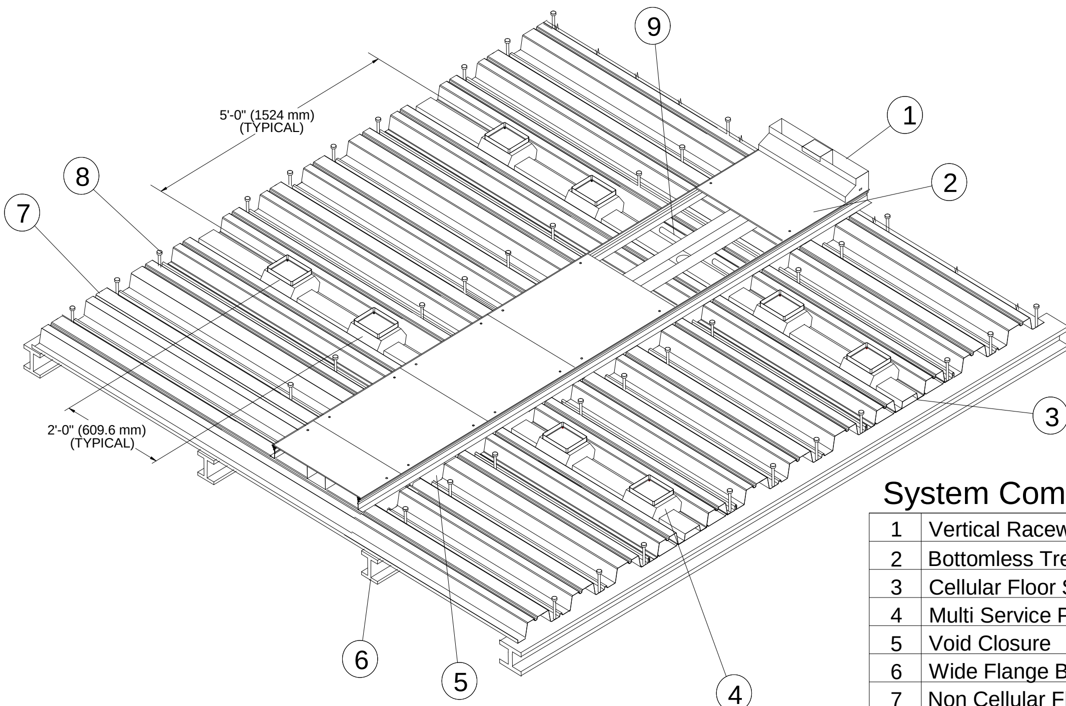
When using a floor box to feed an isolated location, a length of conduit from the floor box to the junction box or underfloor duct, and a conduit adapter shall be installed. If electrical power is one of the services in the floor box, the floor box shall be fully partitioned.

9.10.2 Cellular floor

9.10.2.1 Design guidelines and procedures

9.10.2.1.1 General design information

Service to service areas may be provided by locating the cellular sections on 1220-1525 mm (4-5 ft) centers using a 50% combination of cellular and non-cellular sections. This spacing provides for an alternating arrangement of cellular and non-cellular sections to achieve good coverage and flexibility for service area placement. See figure 16.



System Components

1	Vertical Raceway
2	Bottomless Trench Header
3	Cellular Floor Section
4	Multi Service Preset
5	Void Closure
6	Wide Flange Beam
7	Non Cellular Floor Section
8	Shear Stud
9	Grommet

Figure 16 – Steel cellular floor

9.10.2.1.2 System capacities

9.10.2.1.2.1 General recommendations

To determine cellular floor system requirements for general office space, based on the assumption of three devices per service area and one service area per 10 m^2 (100 ft^2), provide a minimum of 650 mm^2 (1 in^2) of cross sectional area per 10 m^2 (100 ft^2) of usable floor space. This practice applies to capacities of both feeder and distribution cells. Where it is known that the number of devices per service area is greater, or the service area allocation density is greater than this rule, the sizing shall be increased accordingly. Any restrictions and reductions of duct capacity at intersections and turns shall be included in the feeder capacity calculation.

9.10.2.1.2.2 Specific calculation method

Another method to determine capacity requirements involves four factors that affect raceway sizes:

a) area being served;
b) quantity of service areas in that area;
c) size and quantity of cables; and
d) potential changes to service locations.

A sample calculation for distribution cells follows:

a) distribution cell is 1.5 m (5 ft) on center and 24 m (80 ft) long; or 37 m^2 (400 ft^2) being served;
b) service areas in this area are 6 m^2 (64 ft^2) each for a total of 6.25 service areas;
c) three cables are required to each service area. Each cable diameter is 5.538 mm (0.218 in) or, expressed in area, 24.1 mm^2 (0.0373 in^2), for a total of 72.3 mm^2 (0.112 in^2) for each service area; and
d) the 6.25 service areas will be relocated three times without removing existing cables. Therefore, the potential number of service areas is 18.75.

The planned cell capacity required would be for 18.75 service areas multiplied by 72.3 mm^2 (0.112 in^2) or 1355 mm^2 (2.1 in^2) actual cable area. Using a 40% fill factor, the distribution cell capacity for this area would be a minimum of 3387 mm^2 (5.25 in^2).

Feeder calculations are similar and extremely important to the design of the system. A trench header is generally used to meet high capacity requirements as shown in the following example:

a) the area being served from the distributor room is 744 m^2 (8000 ft^2);
b) service areas in this area average 7.4 m^2 (80 ft^2) each or 100 service areas;
c) three cables are required to each service area, same as above, or 72.3 mm^2 (0.112 in^2) each; and
d) the 100 service areas will be relocated three times, same as above, or potentially 300 service areas.

The total feeder capacity entering the distributor room would be 300 service areas multiplied by 72.3 mm^2 (0.112 in^2) or 21 690 mm^2 (33.6 in^2) actual area, divided by 0.4 (40% fill) or 54 225 mm^2 (84 in^2).

9.10.2.1.3 Design and layout information

In cellular steel floor construction, the concrete coverage is typically 64 mm (2.5 in). For cellular concrete construction, this coverage is typically 38 mm (1.5 in). Since the trench header is contained within the concrete topping, the width of the trench header is controlled by this height restriction.

9.10.2.2 Distribution cells in cellular floor

9.10.2.2.1 Preset inserts

Preset inserts shall not be spaced less than 600 mm (24 in) on center.

9.10.2.2.2 Blank cells

A blank cell is a hollow space of a cellular metal or cellular concrete floor section supplied without inserts. Access to blank cells is accomplished by core drilling through the concrete topping and cutting through the top surface of the cell. An afterset insert and service fitting shall then be installed to complete the installation.

9.10.2.3 Feeder systems for cellular floor

9.10.2.3.1 Flush header duct

Flush header duct is only used for cellular concrete systems and consists of upper and lower steel channel sections that can be adjusted to finished floor level. A hole shall be core drilled through the concrete to the cell, and fitted with a grommet. Access units shall be provided in the top section and shall be located over openings into the cells. Each service shall be contained in a separate header duct.

9.10.2.3.2 Header duct

Pre-punched holes and a grommet shall be provided in the bottom of the header duct to align with the appropriate cell.

9.10.2.3.3 Trench header

A trench header used in steel or concrete cellular floor systems shall have removable cover plates through its entire length. Where trench headers cross terrazzo or marble floors, embedded duct should be used.

9.10.2.4 Layout of cellular floor

9.10.2.4.1 Distribution cells

Distribution cells should span the longest length of the building to minimize the length of embedded header runs or trench header. However, the structural layout will determine the direction of the span.

9.10.2.4.2 Allocating distribution cells

In a three-cell cellular floor section, the two outer cells are typically dedicated to telecommunications and the center cell is dedicated to electrical power.

9.10.2.4.3 Feeder

A cellular floor system shall be connected to a distributor room.

9.10.2.5 Installation of cellular floor systems

9.10.2.5.1 General

Cellular and non-cellular floor sections shall be positioned and fastened to the supporting steel frame as shown on the manufacturer's installation drawings. Centerline dimensions of cellular sections, as called out by the installation drawings, shall be held to facilitate locations of preset and afterset inserts after the concrete pour.

9.10.2.5.2 Header duct

The header duct shall be installed on top of and perpendicular to the floor cells with the access units centered over the cells to be activated. Ducts shall be secured to the cells with either hold-down straps or tabs, which are fastened to the inactivated cells or the valley between the cells. Marker assemblies shall be installed at the end of the cells. All openings and joints that may allow concrete to enter the raceway shall be sealed with tape prior to concrete pour. After the concrete is set, access units shall be leveled to the surrounding floor and fitted with grommets between the header duct and the cell. Finishing pans are protective trims that can be used to accommodate the floor finish material, and can be installed on the cover plate of the access unit.

9.10.2.5.3 Trench header

The trench header shall be installed on top of and perpendicular to the floor cells and secured with welds or smooth rivets. Trench header sections shall be installed so that the top surface will be level with the finished concrete floor. For full bottom type trench header, openings from the base of the trench to the appropriate distribution cell shall be cut and fitted with a grommet. Factory punched openings shall be fitted with a grommet. All openings that may allow concrete to enter the raceway shall be sealed prior to concrete pour. Adjustable partitions shall be raised to the underside of the cover plate and welded or bolted in place to support the cover and assure complete separation of the services. Welds shall be painted with a rust-preventing paint. Trench headers should have a flange opening in the cover plate, or a riser boot installed.

9.10.2.6 Service fittings for cellular floor

Service fittings may provide access to one or more services. If electrical power is one of the services, the fitting shall be fully partitioned.

9.11 Perimeter raceways

9.11.1 Construction

Surface raceway systems consist of bases, covers, associated fittings, and accessories. Fittings (e.g., coupler, corner, end cap, adapter, device box) shall be used to connect, change direction, or terminate a surface raceway. Accessories shall provide the means of mounting specific or generic devices (e.g., service area outlet, conduit connection) either internal or external to the raceway system.

Surface raceway systems shall be configured as either single-channel or multi-channel systems. Single-channel systems shall be designed and used for either telecommunications cabling or power cabling. Multi-channel systems shall contain divider wall(s), either pre-configured or modular.

Under conditions of maximum fill, surface raceway systems shall not force cable into a bend radius that is less than the greater of:

a) the minimum bend radius requirement of ANSI/TIA-568-C.0;
b) the manufacturer's recommended minimum bend radius; or
c) 25 mm (1 in).

Surface raceways may have square, rectangular, triangular or semi-circular cross-sectional areas while covers may be flat, concave or convex.

9.11.2 Design and installation requirements

9.11.2.1 Surface raceway system sizing

9.11.2.1.1 Pathway sizing

For planning perimeter pathways, the maximum pathway fill shall be 40%. Pathway (raceway) fill is calculated by dividing the summation of the cross-sectional area of all cables by the most restrictive cross-sectional area of the raceway system. This fill capacity does not consider the additional constrictions caused by service area outlets. Raceway manufacturers shall provide the internal cross-sectional area of each pathway component. Sizing a raceway using 40% cable fill will facilitate the installation of typical telecommunications cables and outlets/connectors as well as provide space for future modifications and expansion to the cabling system.

> **NOTE –** Some raceway fittings and telecommunications outlets/connectors restrict the cross-section of the raceway system (see 9.11.2.1.2 and 9.11.2.1.3).

9.11.2.1.2 Raceway fittings

If the usable cross-section of a raceway system is reduced at fittings in order to maintain the proper bend radius for telecommunications cables, the raceway manufacturer shall make available the resultant cross-sectional area through the fitting based on cable bend radius (e.g., cross-sectional area should be calculated using A2 dimension instead of A1 dimension per figure 17).

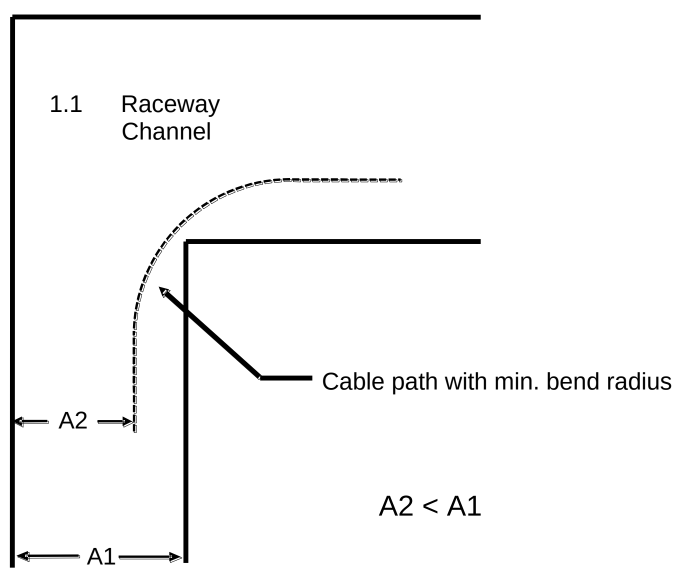


Figure 17 – Reduction of raceway capacity at sharp corners

9.11.2.1.3 Equipment outlets

Equipment outlets mounted internal to a raceway reduce the available cross-sectional area of a raceway system. Designers and installers should consider that the connector may restrict the available cable capacity around the connector.

9.12 Vertical pathway – sleeves or conduits, slots

9.12.1 Sleeve or conduit quantity and configuration

A minimum of five metric designator 103 (trade size 4) conduits or sleeves should be provided to service up to 4000 m^2 (40 000 ft^2) of usable floor space. One additional conduit or sleeve should be provided for each additional 4000 m^2 (40 000 ft^2) of usable floor space. For example, a building with four floors of 2500 m^2 (25 000 ft^2) served from the basement should have a minimum of seven conduits or sleeves based on the total usable floor space of 10 000 m^2 (100 000 ft^2). When the number of sleeves or the area of the pathway requires more than one row of sleeves, designers should restrict the number of rows to two wherever practicable. The location and configuration of sleeves shall be approved by a structural engineer.

See examples in figure 18 and figure 19.

9.12.2 Slot quantity and configuration

Slots are typically located flush against the wall within a space, and should be designed at a depth (the dimension perpendicular to the wall) of 150-600 mm (6-24 in), giving preference to narrower depths wherever possible. The location and configuration of the slot(s) shall be approved by a structural engineer.

The size of the pathway using slots should be one slot sized at 0.04 m^2 (60 in^2) for up to 4000 m^2 (40 000 ft^2) of usable floor space served. The slot area should be increased by 0.04 m^2 (60 in^2) with each 4000 m^2 (40 000 ft^2) increase in usable floor space served. For example, a building with four floors of 2500 m^2 (25 000 ft^2) served from the basement should have a minimum slot area of 0.12 m^2 (180 in^2) based on the total usable floor space of 10 000 m^2 (100 000 ft^2).

See examples in figure 18 and figure 19.

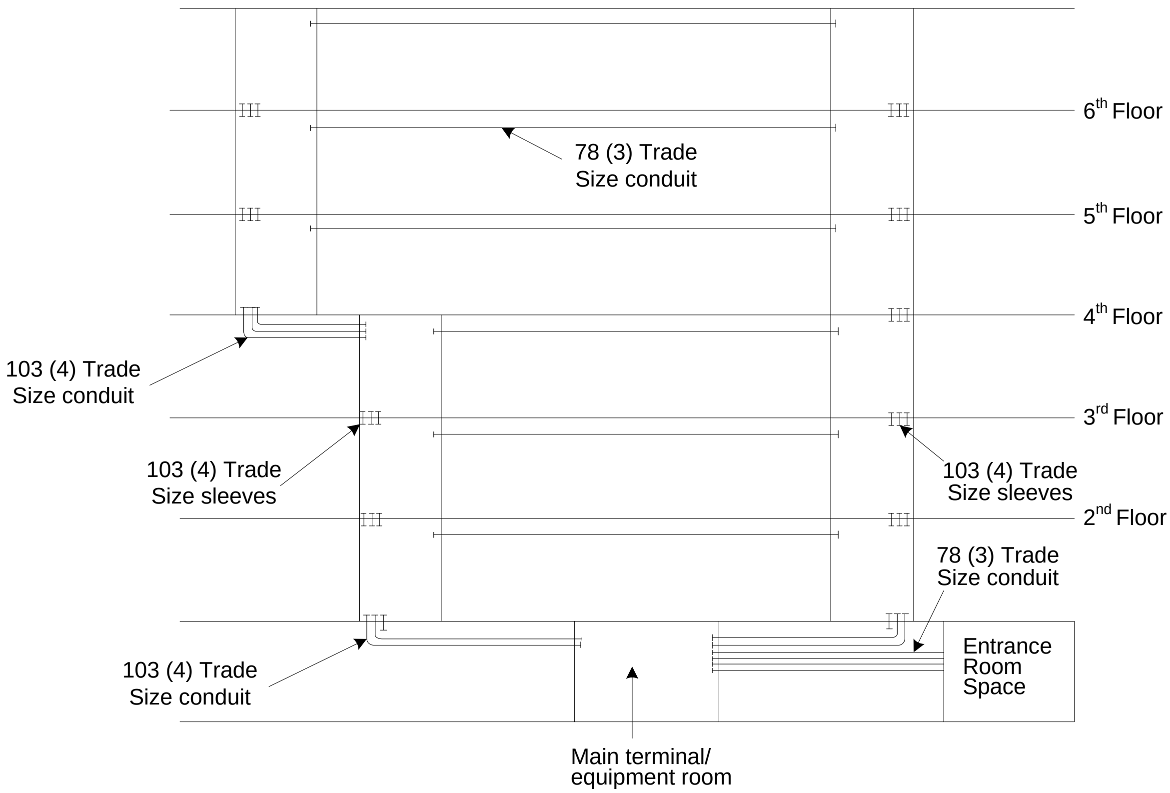


Figure 18 – Typical office building pathway layout

NOTE – With distributor rooms aligned in a vertical pathway, some means for cable pulling should be provided above and in line with the sleeves or slots at the uppermost room of each vertical stack. A steel anchor pulling iron or eye embedded in the concrete is an example. Similar techniques may be required for long building pathways.

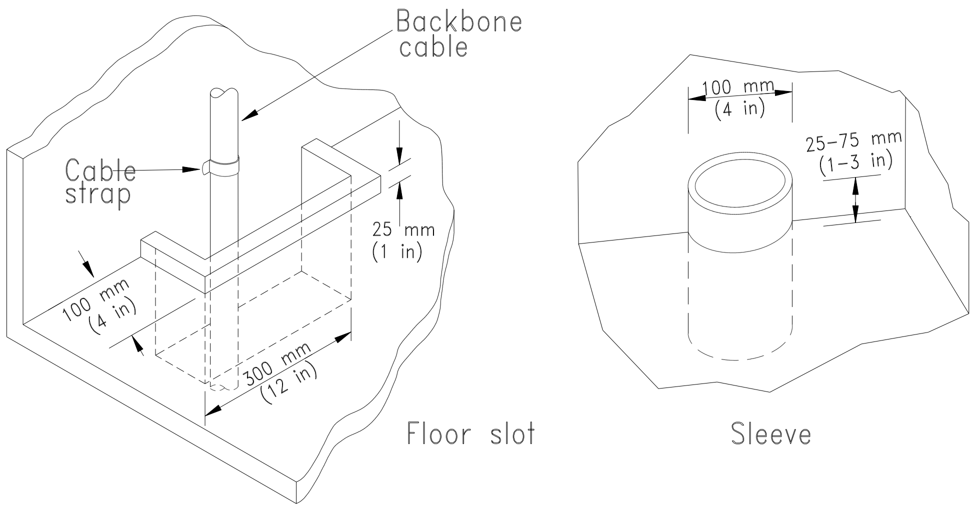


Figure 19 – Typical sleeve and slot installations

9.13 Utility columns

Utility columns should be attached to and supported by main ceiling support channels; they should not be attached to the transverse or short length channels unless they are also rigidly secured to the main support channel. When utility columns are used, the main ceiling rails shall be rigidly installed and braced to overcome movement, both vertical and horizontal.

9.14 Partition cabling

Where demountable partitions are used to conceal the cables, a snap-in panel or cover shall be provided. Alternatively, a demountable partition may be used to conceal the cable if an accessible space or conduit of sufficient size is provided.

9.15 In-wall cabling

A pathway that passes through holes in studs should not have any sharp edges or objects that might cause damage to the cable sheath. Any sharp edges or objects that exist shall be provided with bushings as required.

9.16 Overfloor raceway

Overfloor raceways are not covered by this Standard.

9.17 Curtain wall

Pathways shall not be routed through gaps between the floor or ceiling structure and a curtain wall.

9.18 Open ceiling

Cabling located in open ceilings should be installed in cable tray, cable runway, or conduit, or supported per 9.7.

9.19 Structural columns

Cabling installed on structural columns shall be properly secured and protected from mechanical damage.

Annex A (normative) Firestopping

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

The purpose of this annex is to provide guidelines and formalize requirements concerning firestopping. It is imperative that, in addition to the material presented here, the reader consult their authority having jurisdiction (AHJ) concerning local firestopping requirements. Readers are further encouraged to work directly with firestop manufacturers to provide appropriate drawings that support fire test documentation and other submittals to satisfy the specific requirements of the AHJ for the work being performed.

A.1 Scope

This annex provides guidance toward utilization of standardized specific design and construction practices as well as methods, materials and other considerations for reestablishing the integrity of fire-rated architectural structures and assemblies (e.g., walls, floors, ceilings) when these barriers are penetrated by components.

For firestop installation methods and other additional information, refer to the BICSI *Telecommunications Distribution Methods Manual*.

A.2 Terminology

When referring to firestopping systems, the terms "qualified," "tested," "listed," "classified," and "approved" are essentially synonymous; each refers to firestopping systems that have been tested by an independent laboratory and evaluated as effective (different laboratories use different terms). For simplicity, this annex will use the term "qualified" to represent all of these terms. The terms "system" and "design" are also nearly synonymous; both refer to an arrangement of specific firestopping materials in a specific configuration. The term "system" is used in this context throughout this annex.

See 3.2 for definitions applicable to firestopping.

A.3 Firestops

A.3.1 Introduction

The function of a firestop is to prevent fire, smoke, or water from passing through a barrier penetration. This applies to building construction, renovation, or rehabilitation. In many cases, firestop seals are required to perform secondary functions, in acting as environmental protection seals as well as sealing around penetrations which may reach high temperatures or may move axially or laterally. These requirements must be taken into consideration in the application of firestops.

A.3.2 Fire rated barriers

Commercial buildings are divided into fire zones by fire-rated barriers which are architectural structures or assemblies (e.g., walls, floors, and ceilings). The perimeters of the fire zones are established in accordance with the building codes and construction requirements. Building designers and constructors shall reference reports on barrier materials before choosing an appropriate floor or wall design (load bearing or non-load bearing) for a fire zone perimeter.

> **CAUTION –** The failure of a barrier to perform according to design may have grave consequences if it allows heat, flame, smoke, or gases to pass.

Any disruption in the continuity or integrity of the surface of a fire-rated barrier nullifies the performance rating of the barrier. All penetrations shall be protected by approved firestops.

A.3.3 Penetrations

Penetrations are openings made in fire-rated barriers. There are two kinds of penetrations. Membrane penetrations pierce or interrupt the outside surface of only one side of a fire-rated barrier. Through penetrations completely transit a fire-rated barrier, piercing both outside surfaces of the barrier. Penetrations are made to install building elements (e.g., conduits, cables, piping, fixtures, boxes, ducts) and must be firestopped to return the barrier to its intended fire rating.

No additional firestopping is needed for electrical apparatus (e.g., boxes, junction boxes, breaker panels and fixtures) that have been tested and approved for use in fire-rated assemblies other than normal patching where the item penetrates a fire-rated assembly. Receptacles and switch boxes shall be firestopped on the back side of the units where jurisdiction mandates. Installation criteria shall be listed in the installation instructions in order for the AHJ to issue a certificate of occupancy.

A.3.4 Evaluation of firestop systems

Firestops are specific combinations of materials installed and (possibly) supported or anchored in a certain way. They are qualified by independent agencies, based on the materials performance when tested in a particular configuration.

It is not possible to test every arrangement of firestops. Many test assemblies are based on testing of worst case in a number of variables and must demonstrate an ability to perform despite the mass of thermal-conducting elements expected to penetrate openings (e.g., a heavily loaded cable tray containing PVC-jacketed cable bundles).

> **NOTE –** The fact that a material is noncombustible does not qualify that material as a firestop unless it has passed performance testing as a through penetration firestop following ASTM E814 or ANSI/UL 1479.

A.3.5 Qualification testing

Testing of firestop systems provides evidence of the system's performance across a range of variable conditions known or expected to exist in a sealing situation.

If metallic sleeves are to be used for the pathway for cables through a barrier (e.g., two-hour rated gypsum wallboard or three-hour rated poured concrete construction) there shall be verifiable test programs (ASTM E814 or ANSI/UL 1479) by using this pass-through method.

A.3.6 Testing requirements for through-penetration firestops

The fire resistivity of through-penetration firestops is evaluated under positive pressure, "time-versus-temperature" furnace conditions. This testing allows the resistivity to be assessed through controlled fire exposure. For fire resistivity testing guidelines and evaluation material, refer to standards: ASTM E119, ASTM E814, ANSI/UL 1479.

A.3.7 Firestop ratings for through-penetration firestops

Two rating classifications for firestops are available under the rating criteria of ASTM E814; they may be relevant in assessing the fire hazard of a particular application:

a) F (hours) withstands the test fire for the rating period without:
   1) permitting flames to pass through the firestop;
   2) permitting flame to occur on any element of the unexposed side of the firestop (e.g., autoignition); or
   3) developing any opening in the firestop during the hose stream test that permits a projection of water beyond the unexposed side;

b) T (hours) meets the criteria for an "F Rating" and limits temperature rise during the rating period. The temperature on any unexposed surface can increase no more than 181 °C (325 °F) plus ambient.

An optional classification, found in ANSI/UL 1479 but not in ASTM E 814, is:

c) L (Air Leakage) addresses the issue of leakage by reporting a number value:
   1) a lower number equals a better "L" rating;
   2) the temperatures of the exposed face of the test sample is to be 24 °C ± 11 °C (75 °F ± 20 °F) prior to the conduct of the test; and
   3) total metered air flow is to be recorded at ambient temperature and repeated at a test chamber temperature of 204 °C ± 5 °C (400 °F ± 10 °F).

   NOTE – See ANSI/UL 1479 for preconditioning of the test specimen and chamber requirements.

A.3.8 Guidelines for membrane-penetration firestops

There are no specific test standards for qualifying or rating membrane-penetration firestops although guidelines can be found in various building codes. The reader shall check with the AHJ for local membrane-penetration requirements. In most cases, the guidelines require additional buildup of the wall opposite the membrane penetration or the installation of firestop pads on the back side of the membrane penetrant (i.e., receptacle and switch boxes).

A.3.9 Seismic considerations

The firestopping specification shall accommodate the applicable seismic zone requirements.

A.3.10 Engineering judgments

The large number of combinations of construction elements found in the real world creates application conditions falling outside the envelope of tested systems. As these conditions cannot be ignored, there is usually no alternative but to rely on an engineering judgment. Such judgments must be based on sound practice to ensure that life safety issues are not compromised. These judgments:

a) should only be obtained from qualified technical personnel of a manufacturer of the firestop materials;

b) should be based upon full knowledge of the elements of the construction to be protected and an understanding of the probable behavior of that construction under ASTM E814 fire test conditions for the required rating period;

c) should be limited to the specific conditions and configurations upon which the judgment was based; and
d) should be issued only for a specific job and location, and not transferred to any other job or location without appropriate review.

A.4 Quality control considerations

Components used in firestop systems shall be the same as the products used in fire qualification tests, must be prepared and installed using established quality control procedures, and verified periodically by an independent quality auditor at the manufacturer's facility. The final field installation shall be reviewed and validated by the local AHJ.

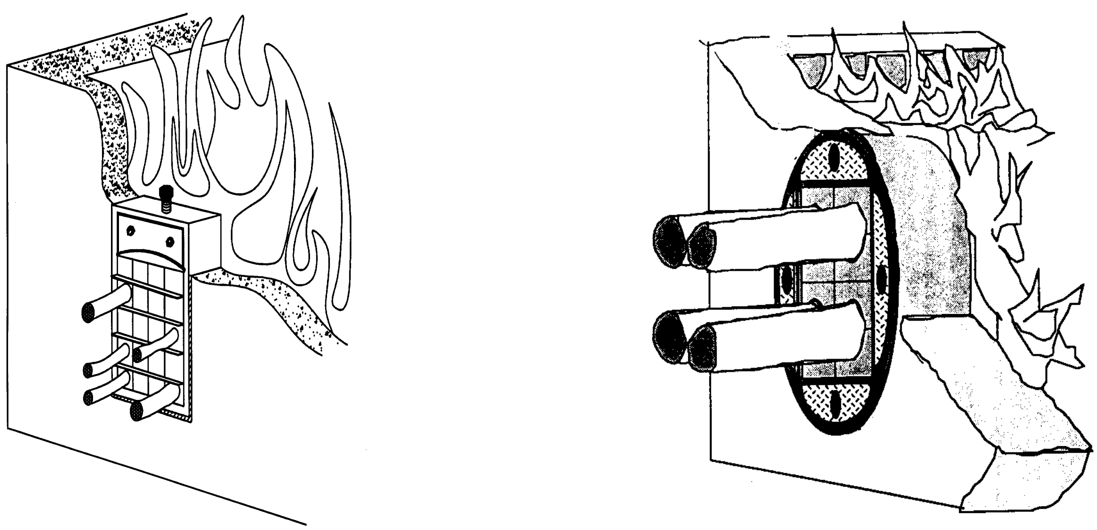
A.5 Categories of firestop systems

A.5.1 Introduction

Firestop systems can be roughly divided into two broad categories; mechanical and nonmechanical.

A.5.2 Mechanical systems

Mechanical systems consist of premanufactured elastomeric components shaped to fit around standard cables, tubes and conduits. The elastomeric modules are fitted around penetrating elements and arrayed within the frame, as shown in figure 20.



Rectangular Round

Figure 20 – Mechanical firestops

The most useful systems are highly modular to ensure maximum flexibility in accepting multiple elements of different diameters. Frame and hardware components shall be steel to survive test temperatures.

Systems that do not use frames are intended to fit standard conduits, sleeves or cored holes. Whether or not frames are included, some means of applying compression to the modules is required to establish a tight seal. The elastomer is specially designed to withstand the fire and hose stream test for the rated time.

Mechanical firestop systems are considered highly durable, provide reliable pressure and environmental sealing, have excellent resistance to shock and seismic vibration, support the penetrating elements, can provide EMI protection and the opportunity to reconfigure the penetrating elements as required.

A.5.3 Nonmechanical systems

Nonmechanical firestop systems come in a variety of forms, each having desirable properties for specific situations. They share the common benefit of adapting to irregular openings and off-center penetrating items. These nonmechanical firestop materials are available in the form of putties, caulks, cementitious materials, intumescent sheets, intumescent wrap strips, silicone foam, and premanufactured pillows.

A.5.3.1 Putty

Most putties are intumescent and are available in bars, sticks, pads, or tubes. Some putties have the consistency of glazing putty, remain soft and pliable, and allow easy firestop reentry. They shall be installed in conjunction with ceramic fiber, rock wool filler or other approved fill materials. Tube putty, which cures to an elastomeric solid, is used with a ceramic fiber base, and requires new material any time the seal is reopened to add or change cables. Putties are easier to reenter than caulks.

Systems are available that allow complete installation of a putty seal from one side of a penetration.

Putty pads are used to seal the back of outlet boxes or other electrical fixtures installed in a membrane penetration. Pads are also used in conjunction with other firestop materials to create firestopping systems. Testing indicates that the putty pad prevents flame through an undesirable heat buildup on the non-fire side of the wall. The pad seals knockouts, openings in the fixture, and prevents smoke from entering hollow wall cavities.

A.5.3.2 Caulk

Several firestop materials are available in caulk form. All these materials set up after a relatively short time to form a tight seal and are dispensed either from standard caulk tubes or large pails. The types of caulk vary somewhat in their ability to adhere to various surfaces, their flexibility, moisture resistance, and the quantity required for a rated firestop seal. Firestop caulks vary in composition, are water based, 100% solids, or solvent based, and typically are intumescent, endothermic and ablative. Some caulking materials can be installed from the underside of an opening without dripping or slumping.

> **CAUTION –** Solvent based caulk seals that give off toxic or noxious fumes should not be used in confined areas that are not well ventilated.

A.5.3.3 Cementitious (cement-like) materials

These materials are a dry powder premixed or mixed with water and more adaptable to large openings than putty or caulk. When using cementitious materials, it may be necessary to allow for thermal expansion or motion of the penetrating item. Plaster or ordinary grout shall not be used as a cementitious firestop. Seals made of grout or plaster may crack, fracture, or fall out, and may be extremely difficult to re-penetrate.

A.5.3.4 Intumescent sheets

Intumescent sheets with a sheet metal backing can be used to seal large openings or non-sheet metal sheets may be used with caulk or putty to fabricate a honeycomb-like partitioned opening for cable, conduit, metal or nonmetallic pipe. When using intumescent sheets, manufacturer's instructions shall be followed for anchoring and sealing.

A.5.3.5 Intumescent wrap strips

Intumescent wrap strips are usually used for firestopping plastic piping, insulated metal piping, cable, cable bundles, nonmetallic conduit, exposed innerduct, or any other material that may burn away in a fire and leave a significant void. Intumescent strips may also be used to increase fire endurance. Wrap or blankets are relatively soft and permit easy installation around penetrating elements.

A.5.3.6 Silicone foams

Early nonmechanical firestop systems were based on two-component silicone foams. Mixed in proper proportions at the right temperature, the two components expanded rapidly to form a cellular structure surrounding the penetrating items. This method is mainly used for large openings and the opening must be made structurally adequate and leak-tight to resist and control the expansive forces of the foam.

A.5.3.7 Premanufactured pillows

Premanufactured pillows are a recent development in firestop sealing. Unlike earlier pillows, which contained noncombustible fibers, contemporary pillows contain a specially treated, compressible fiber matrix. When exposed to fire, the matrix swells to provide further sealing, becomes rigid allowing the pillow seal to withstand the force of a hose stream as required by fire test standards. Pillows are often mistakenly regarded as temporary firestops because of their convenience. However, pillow fire-test qualification standards are the same as for any other sealing system.

> **NOTE –** Some pillows must be restrained by a wire mesh or a metallic sheet for support.

A.6 Design consideration checklist

Use the following checklist to assist in meeting the requirements of the owner, the application, and the AHJ:

a) type of installation:
    1) one side – when access to the other side is impossible;
    2) installation from the bottom because of material characteristics that prevent the installation of the seal when the top of the opening is not accessible because of equipment location;
    3) floor, wall, or ceiling installation; and
    4) no additional firestopping is needed for electrical apparatus (e.g., boxes, junction boxes, breaker panels and fixtures) that have been tested and approved for use in fire-rated assemblies other than normal patching where the item penetrates a fire-rated assembly. Receptacles and switch boxes shall be firestopped on the back side of the units where jurisdiction mandates. Installation criteria shall be

listed in the installation instructions in order for the AHJ to issue a certificate of occupancy;

b) barrier penetration:
   1) round, square;
   2) concrete block, solid concrete, brick, gypsum wall board etc.; and
   3) does it have penetrating items installed and what are they?;
c) the opening:
   1) diameter, or length and width;
   2) depth;
   3) access (single side or both sides);
   4) room location;
   5) penetrating items (approximate percent filled); and
   6) special features - steel sleeve or insulation;
d) firestop requirements:
   1) environmental;
   2) cable management;
   3) pressure barrier;
   4) cold smoke or gas seal; and,
   5) special requirements (such as an EMI barrier);
e) penetrating items:
   1) cables (by size and quantity);
   2) pipes (by type and quantity);
   3) cable tray or no cable tray;
   4) any other unique penetrating items; and
   5) insulation on any penetrating item;
f) code requirements:
   1) national;
   2) state; and
   3) local; and
g) test specifications:
   1) ASTM;
   2) UL;
   3) military; and
   4) what are the test parameters?

Annex B (informative) Electromagnetic noise reduction guidelines for balanced twisted-pair cabling

This annex is informative and is not considered part of this Standard.

B.1 General

The information found in the normative sections of this Standard describes telecommunications infrastructures that exhibit immunity to noise in areas with an environmental classification of E_1. This annex should be used as a reference in those exceptional cases where such a typical environment does not exist, and noise is present on the telecommunications infrastructure.

The existence of high levels of noise on power branch circuits (in the form of surges, or other signals with high frequency content) is an abnormal and unacceptable condition for operation of electrical equipment connected to the circuit. Under such conditions, the typical approach should be to identify, isolate or eliminate the potential noise sources on power branch circuits, or to suppress the noise signals using line conditioners or surge protection. In situations where these sources or signals cannot be removed, the level of expected noise signal should be determined and compared to the base levels outlined in this annex to determine the need for noise coupling reduction.

> **NOTE –** Noise coupling from power branch circuits is not the only noise source that may cause application errors. There are other sources of noise, and other factors that may cause errors or delays in applications.

B.2 Building cabling configurations and noise coupling conditions

The level of coupled noise is determined by:

a) the magnitude, duration and the frequency of noise transients on the power cable;
b) the configuration of the power wires, whether loosely or tightly bundled;
c) the proximity of the cables to grounded metallic surfaces and grounding conditions;
d) the cabling permanent link or channel length;
e) the coupled length between power and telecommunication cables;
f) the balance of the telecommunications cabling; and
g) the separation between the power and telecommunications cables.

The effect of the coupled noise on network operation is quantified by the number of incremental errors caused by exposure to the noise signals that do not occur in the absence of that noise.

It should be noted that the EFT testing using repetitive 500 V pulses represents a worst case condition that is unlikely to be encountered in areas with an environmental classification of E_1. If the existing or expected noise environment does not exceed the above conditions, no further noise reduction considerations or actions are necessary.

B.3 Test configuration

The general test configuration is illustrated in figure 21.

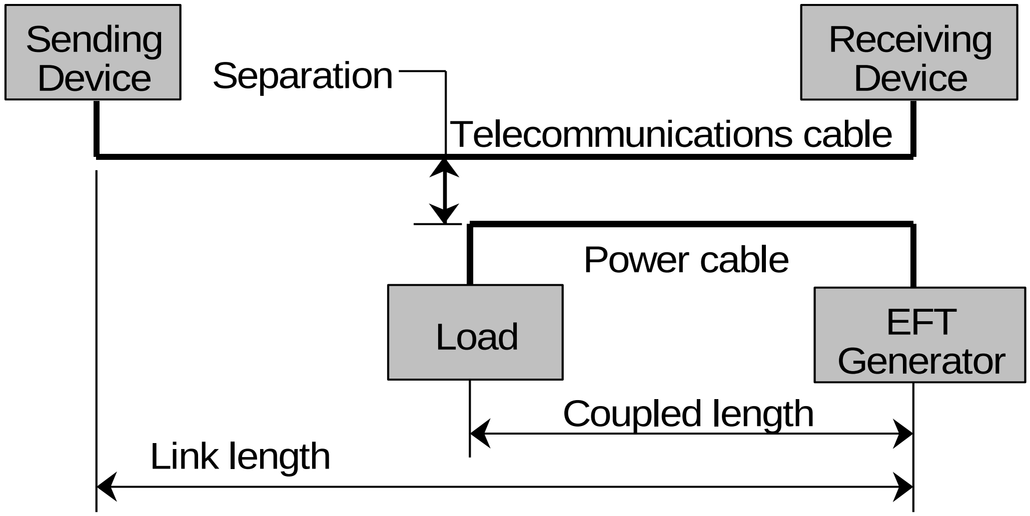


Figure 21 – Test configuration for noise immunity measurements

For packet error rate measurements the telecommunications cable is connected between a sending device and a receiving device. For common mode and differential mode noise measurements, the receiving device is a digital oscilloscope.

The noise source on the power cable is electrical fast transient (EFT) burst generator per IEC 61000-4-4 with a 5 ns rise time, 50 ns pulse duration, 15 ms bursts, 300 ms burst period.

B.4 Test results

The test results using 1000BASE-T are summarized in table 8 in a way that provides the end user with an indication of the relative effect of different variables on the noise coupling between power and telecommunications cables. The variables that were studied include: the effect of pair balance (TCL) characteristics when tested per ANSI/TIA568-C.2, the effect of 1000BASE-T network interface cards (NIC) from three different manufacturers, the effect of different coupled lengths, link lengths and pair separation distances as illustrated in figure 21.

Table 8 – Noise reduction factors under different test variables

Test Variable	Reduction Factor
Effect of cable balance	
TCL > 40 dB from 1 to 30 MHz	1
TCL > 50 dB from 1 to 30 MHz	0.5
Effect of cable category	
Category 5e	1
Category 6	0.5
NIC performance	
Good	1
Poor	2
Effect of coupled length near equipment	
Length = 90m	1
Length = 10m	1
Length < 2m	0.7
Effect of link length	
Length = 90 m	1
Length = 60 m	0.7
Length = 40 m or less	0.6
Effect of separation distance	
Zero (~ 6 mm)	1
1 inch (25 mm)	0.8
2 inch (50 mm)	0.6
3 inch (75 mm)	0.5
6 inch (150 mm)	0.3
Effect of Power Cabling	
Unbundled power conductors	1.0
Bundled power conductors	0.7

NOTES:

1 The noise reduction factor is the ratio of the relative noise immunity between two different test conditions, as measured using a digital oscilloscope or using packet error rate measurements.

2 As a reference benchmark (Reduction Factor = 1), a 500V EFT burst pattern on the power cable is the threshold voltage level for the onset of errors under the following conditions:
- 90 meter link length between two 1000BASE-T Ethernet switch ports;
- Zero separation;
- ≥ 10 meter coupling length;
- Category 5e cabling.

B.5 Summary

The empirical measurements contained in this annex provide an indication of the relative effect of different variables on the noise coupling between adjacent telecommunications and power cabling. One or more techniques can be effective to mitigate the noise coupling from power line transients. Some techniques that can be considered for noise mitigation include:

a) qualification of the network interface card (NIC) for noise immunity;
b) use of category 6 or higher (e.g., category 6A) cabling;
c) use of shielded cabling;
d) use of bundled or jacketed power conductors;
e) reduce coupled lengths near the equipment;
f) reduce link lengths;
g) increase separation distance; and
h) avoid parallel paths between power and telecommunications cables.

Annex C (informative) Bibliography

This annex is informative and is not considered part of this Standard.

The following is a list of some generally applicable basic standards and guides that are relevant to the requirements of this Standard. Other American National Standards also may be relevant.

- ANSI/ICEA S-80-576-2002, *Standard for Category 1 & 2 Individually Unshielded Twisted Pair Indoor Cables (With or Without an Overall Shield) for Use in Communications Wiring Systems Technical Requirements*
- ANSI/ICEA S-83-596-2001, *Standard for Fiber Optic Premises Distribution Cable*
- ANSI/ICEA S-87-640-2006, *Standard for Fiber Optic Outside Plant Communications Cable*
- ANSI/ICEA S-104-696-2001, *Standard for Indoor-Outdoor Optical Cable*
- IEEE C2-2007, *National Electrical Safety Code®*
- ANSI/TIA-598-C 2005, *Optical Fiber Cable Color Coding*
- BICSI *Information Transport Systems Installation Methods Manual (ITSIMM), 6th Edition*, 2010
- BICSI *Outside Plant Design Reference Manual (OSPDRM), 5th Edition*, 2010
- IEC 60825-2-2010, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)*
- TIA TSB-185 2009, *Environmental Classification (MICE) Tutorial*

The organizations listed below can be contacted to obtain reference information.

ANSI
American National Standards Institute
25 W 43rd Street, 4th Floor
New York, NY 10036
USA
(212) 642-4900
www.ansi.org

ASHRAE
American Society of Heating, Refrigerating and Air-Conditioning Engineers
1791 Tullie Circle, NE
Atlanta, GA 30329
USA
(800) 527-4723
www.ashrae.org

ASTM
ASTM International
100 Barr Harbor Drive
PO Box C700
West Conshohocken, PA 19428-2959
USA
(610) 832-9500
www.astm.org

ATIS
Alliance for Telecommunications Industry Solutions
1200 G Street NW
Suite 500
Washington, DC 20005
USA
(202) 628-6380
www.atis.org

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

CISCA
Ceilings and Interior Systems Construction Alliance
405 Illinois Avenue
Unit 2B
St Charles, IL 60174
USA
(630) 584-1919
www.cisca.org

ECA
Electronic Components Association
2500 Wilson Blvd
Arlington, VA 22201
USA
www.ec-central.org

FCC
Federal Communications Commission
445 12th Street SW
Washington, DC 20554
USA
(888) 225-5322
www.fcc.gov

ICEA
Insulated Cable Engineers Association, Inc
PO Box 1568
Carrolton, GA 30112
USA
(770) 830-0369
www.icea.net

IEC
International Electrotechnical Commission
3, rue de Varembe
PO Box 131
1211 Geneva 20
Switzerland
+41 22 919 02 11
www.iec.ch

IEEE
IEEE
10662 Los Vaqueros Circle
P.O. Box 3014
Los Alamitos, CA 90720-1264
USA
(714) 821-8380
www.ieee.org

NEMA
National Electrical Manufacturers Association
1300 N. 17th St
Suite 1752
Rosslyn, VA 22209
USA
(703) 841-3200
www.nema.org

NFPA
National Fire Protection Association
1 Batterymarch Park
Quincy, MA 02169-7471
USA
(617) 770-3000
www.nfpa.org

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

UL
Underwriters Laboratories, Inc
333 Pfingsten Rd
Northbrook, IL 60062
USA
(877) 854-3577
www.ul.com

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