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TIA STANDARD

Telecommunications Infrastructure Standard for Data Centers

TIA-942-A
(Revision of TIA-942)

August 2012

TELECOMMUNICATIONS INDUSTRY ASSOCIATION

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Telecommunications Infrastructure Standard for Data Centers

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FOREWORD

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

Approval of this Standard

This Standard was approved by the Telecommunications Industry Association (TIA) Subcommittee TR 42.1, TIA Technical Engineering Committee TR 42, and the American National Standards Institute (ANSI).

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 At that time, standards are reaffirmed, revised, or withdrawn according to the submitted updates.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

Contributing organizations

More than 60 organizations within the telecommunications industry contributed their expertise to the development of this Standard (including manufacturers, consultants, end users, and other organizations).

The TR-42 Committee contains the following subcommittees that are related to this activity:

- TR-42.1, *Commercial Building Telecommunications Cabling*
- TR-42.2, *Residential Telecommunications Infrastructure*
- TR-42.3, *Commercial Building Telecommunications Pathways and Spaces*
- TR-42.4, *Outside Plant Telecommunications Infrastructure*
- TR-42.5, *Telecommunications Infrastructure Terms and Symbols*
- TR-42.6, *Telecommunications Infrastructure and Equipment Administration*
- TR-42.7, *Telecommunications Copper Cabling Systems*
- TR-42.9, *Industrial Telecommunications Infrastructure*
- TR-42.11, *Optical Systems*
- TR 42.12, *Optical Fiber and Cables*
- TR 42.13, *Passive Optical Devices and Components*
- TR-42.16, *Premises Telecommunications Bonding & Grounding*

Documents superseded

This Standard replaces ANSI/TIA-942 dated April 12, 2005 and its addenda.

This Standard incorporates and refines the technical content of:

- ANSI/TIA-942, Addendum 1, *Data Center Coaxial Cabling Specifications and Application Distances*
- ANSI/TIA-942, Addendum 2, *Additional Guidelines for Data Centers*

Major modifications from ANSI/TIA-942

The major modifications in ANSI/TIA-942-A from ANSI/TIA-942 include:

- ANSI/TIA-942-A has been harmonized with the TIA-568-C series including the topology, terms, and environmental classifications described in ANSI/TIA-568-C.0 and component specifications in ANSI/TIA-568-C.2 and ANSI/TIA-568-C.3

- The content of the addenda - ANSI/TIA-942-1 and ANSI/TIA-942-2 - has been incorporated into this Standard and these two documents will be superseded at the time of publication of ANSI/TIA-942-A.
- Grounding and bonding content from ANSI/TIA-942 has been removed and incorporated into ANSI/TIA-607-B.
- Administration content has been removed and incorporated into ANSI/TIA-606-B.
- Most content regarding cabinets/racks and power/telecommunications separation has been removed and incorporated into ANSI/TIA-569-C.
- Outside plant pathways content has been removed and incorporated into to ANSI/TIA-758-B.
- Removed 100 meter length limitation for optical fiber horizontal cabling. Horizontal cabling distances for optical fiber are based on individual application requirements.
- Category 3 and category 5e are no longer recognized for horizontal cabling. Recognized balanced twisted-pair cable types for horizontal cabling are category 6 or category 6A.
- Recognized multimode optical fiber cable for horizontal and backbone cabling has been changed to OM3 and OM4 850 nm laser-optimized 50/125 μm multimode optical fiber cable, with OM4 recommended. OM1 and OM2 are no longer recognized in this standard.
- Recognized optical fiber connectors are LC for one or two fibers and MPO for more than two optical fibers.
- The Intermediate Distribution Area (IDA) has been added to the data center topology.
- Allowance for active components in the ZDA has been removed.
- Recommendations for energy efficiency have been added.
- The terms “Equipment Outlet” (EO) and “External Network Interface” (ENI) from ISO/IEC 24764 have been added.

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:

- ANSI/TIA-568-C.0, *Generic Telecommunications Cabling for Customer Premises*
- ANSI/TIA-568-C.1, *Commercial Building Telecommunications Cabling Standard*
- ANSI/TIA-568-C.2, *Balanced Twisted-Pair Telecommunications Cabling and Components standard*
- ANSI/TIA-568-C.3, *Optical Fiber Cabling Components Standard*
- ANSI/TIA-569-C, *Telecommunications Pathways and Spaces*
- ANSI/TIA-606-B, *Administration Standard for Telecommunications Infrastructure*
- ANSI/TIA-607-B, *Telecommunications Bonding and Grounding (Earthing) for Customer Premises*
- ANSI/TIA-758-B, *Customer-Owned Outside Plant Telecommunications Infrastructure Standard*

Following is the schematic relationship between the ANSI/TIA-568-C series and other relevant standards:

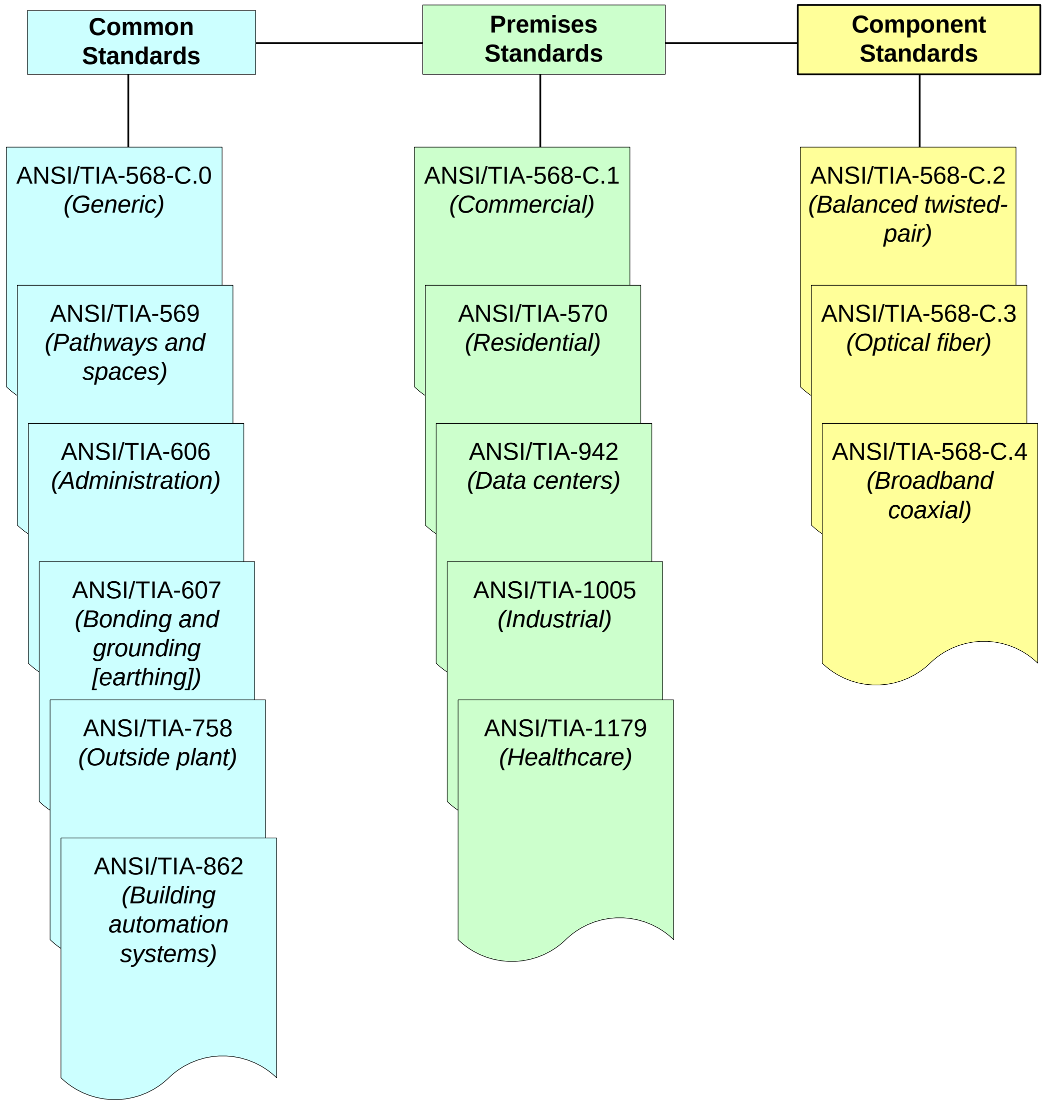


Figure 1: Illustrative relationship between the ANSI/TIA-568-C Series and other relevant TIA standards

This Standard contains references to national and international standards as well as other documents when appropriate.

- *National Electrical Safety Code®* (*NESC®*) (IEEE C 2)
- *Life Safety Code®* (NFPA 101)
- *National Electrical Code®* (*NEC®*) (NFPA 70)
- *Standard for the Protection of Information Technology Equipment* (NFPA 75)
- *Recommended Practice for Powering and Grounding Electronic Equipment* (IEEE Std. 1100)
- *Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications* (IEEE Std. 446)
- Telcordia general requirements: GR-63-CORE (NEBS) and GR-139-CORE
- 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

In Canada, the *National Building Code*, the *National Fire Code*, *Canadian Electrical Code* (CSA CEC C22.1), and other documents including CAN/ULC S524, CAN/ULC S531 may be used for cross-reference to NFPA 72, NFPA 70 section 725-8 and section 725-54.

Useful supplements to this Standard are the BICSI *Telecommunications Distribution Methods Manual,* the *Outside Plant Design Reference Manual,* and the *Information Transport Systems Installation Methods Manual*. These manuals provide recommended practices and methods by which many of the requirements of this Standard may be implemented.

Other references are listed in annex H.

Annexes

Annexes A, B, C, D, E, F, G and H are informative and not considered to be requirements of this Standard.

Purpose of this Standard

The purpose of this Standard is to provide requirements and guidelines for the design and installation of a data center or computer room. It is intended for use by designers who need a comprehensive understanding of the data center design, including the facility planning, the cabling system, and the network design. The standard will enable the data center design to be considered early in the building development process, contributing to the architectural considerations, by providing information that cuts across the multidisciplinary design efforts, promoting cooperation in the design and construction phases. Adequate planning during building construction or renovation is significantly less expensive and less disruptive than after the facility is operational. Data centers in particular can benefit from infrastructure that is planned in advance to support growth and changes in the computer systems that the data centers are designed to support.

This document presents an infrastructure topology for accessing and connecting the respective elements in the various cabling system configurations currently found in the data center environment. In order to determine the performance requirements of a generic cabling system, various telecommunications services and applications were considered. In addition, this document addresses the floor layout related to achieving the proper balance between security, rack density, and manageability.

The standard specifies a generic telecommunications cabling system for the data center and related facilities whose primary function is information technology. Such application spaces may be dedicated to a private company or institution, or occupied by one or more service providers to host Internet connections and data storage devices.

Data centers support a wide range of transmission protocols. Some of these transmission protocols impose length restrictions that are shorter than those imposed by this Standard. Consult: standards, regulations, equipment vendors, and system service suppliers for: applicability, limitations, and ancillary requirements when applying specific transmission protocols. Consider consolidating standardized and proprietary cabling into a single structured cabling system.

Data centers can be categorized according to whether they serve the private domain ("enterprise" data centers) or the public domain (internet data centers, co-location data centers, and other service provider data centers). Enterprise facilities include private corporations, institutions or government agencies, and may involve the establishment of either intranets or extranets. Internet facilities include traditional telephone service providers, unregulated competitive service providers and related commercial operators. The topologies specified in this document, however, are intended to be applicable to both in satisfying their respective requirements for connectivity (internet access and wide-area communications), operational hosting (web hosting, file storage and backup, database management, etc.), and additional services (application hosting, content distribution, etc.). Failsafe power, environmental controls and fire suppression, and system redundancy and security are also common requirements to facilities that serve both the private and public domain.

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.

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 the absolute minimum acceptable requirements. Advisory or desirable criteria are presented when their attainment will 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 for offering informative suggestions.

Metric equivalents of US customary units

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

Life of this Standard

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

1 SCOPE

This Standard specifies the minimum requirements for telecommunications infrastructure of data centers and computer rooms, including single tenant enterprise data centers and multi-tenant Internet hosting data centers. The topology specified in this document is intended to be applicable to any size data center.

2 NORMATIVE REFERENCES

The following standard contains provisions that, through references in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards published by them.

a) ANSI/TIA-568-C.0, *Generic Telecommunications Cabling for Customer Premises*

b) ANSI/TIA-568-C.1, *Commercial Building Telecommunications Cabling Standard*

c) ANSI/TIA-568-C.2, *Balanced Twisted-Pair Telecommunications Cabling and Components Standard*

d) ANSI/TIA-568-C.3, *Optical Fiber Cabling Components Standard*

e) ANSI/TIA-569-C, *Telecommunications Pathways and Spaces*

f) ANSI/TIA-604.5-D, *FOCIS 5 – Fiber Optic Connector Intermateability Standard, Type MPO*

g) ANSI/TIA/EIA-604-10-A, *FOCIS 10 – Fiber Optic Connector Intermateability Standard, Type LC*

h) ANSI/TIA-606-B, *Administration Standard for Telecommunications Infrastructure*

i) ANSI/TIA-607-B, *Telecommunications Bonding and Grounding (Earthing) for Customer Premises*

j) ANSI/TIA-758-B, *Customer-Owned Outside Plant Telecommunications Infrastructure Standard*

k) ANSI/NFPA 70-2011, *National Electrical Code®*

l) ANSI/NFPA 75-2009*, Standard for the Protection of Information Technology Equipment®*

m) ANSI/ATIS-0600404.2002(R2006), *Network and Customer Installation Interfaces – DS3 and Metallic Interface Specification*

n) ASHRAE, *Guidelines for Data Processing Environments, Second Edition*, 2009

o) ASHRAE *2011 Thermal Guidelines for Data Processing Environments – Expanded Data Center Classes and Usage Guidance*, 2011

p) OSHA CFR 1926.441, *Battery Rooms and Battery Charging*

q) Telcordia GR-63-CORE, *NEBS(TM) Requirements: Physical Protection*

r) Telcordia GR-139-CORE, *Generic Requirements for Central Office Coaxial Cable*

3 DEFINITION OF TERMS, ACRONYMS AND ABBREVIATIONS, AND UNITS OF MEASURE

3.1 General

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

3.2 Definition of terms

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

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.

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

backbone: A facility (e.g., pathway, cable or bonding conductor) for cabling Subsystem 2 and Cabling Subsystem 3.

backbone cable: See **backbone**.

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

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.

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

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

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

Cabling Subsystem 3: Cabling between Distributor B and Distributor C.

centralized cabling: A cabling configuration from an equipment outlet to a centralized cross-connect using a continuous cable, an interconnection, or a splice.

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

common equipment room (telecommunications): An enclosed space used for equipment and backbone interconnections for more than one tenant in a building or campus.

computer room: An architectural space whose primary function is to accommodate data processing equipment.

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 below:

Metric Designator	Trade Size
16	1/2
21	3/4
27	1
35	1 1/4
41	1 1/2
53	2
63	2 1/2
78	3
91	3 1/2
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.

cord (telecommunications): An assembly of cord cable with a plug on one or both ends.

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.

data center: A building or portion of a building whose primary function is to house a computer room and its support areas.

demarcation point: A point where the operational control or ownership changes.

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).

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.

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.

earthing: See grounding.

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

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 cabling takes place.

equipment cord: See **cord.**

equipment distribution area: The computer room space occupied by equipment racks or cabinets.

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

equipment room (telecommunications): An environmentally controlled centralized space for telecommunications equipment that usually houses Distributor B or Distributor C.

external network interface: Interface between the computer room cabling and external cabling.

fiber optic: See **optical fiber**.

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.

grounding conductor: A conductor used to connect the grounding electrode to the building's main grounding busbar.

horizontal cabling: Cabling Subsystem 1.

horizontal cross-connect: Distributor A.

horizontal distribution area: A space in a data center where a horizontal cross-connect is located.

identifier: An item of information that links a specific element of the telecommunications infrastructure with its corresponding record.

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.

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

intermediate cross-connect: Distributor B.

intermediate distribution area: A space in a data center where an intermediate cross-connect is located.

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

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

liquidtight: Impervious to moisture ingress.

main cross-connect: Distributor C.

main distribution area: The space in a data center where the main cross-connect is located**.**

mechanical room: An enclosed space serving the needs of mechanical building systems.

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

modular jack: A female telecommunications connector that may be keyed or unkeyed and may have 6 or 8 contact positions, but not all the positions need be equipped with jack contacts.

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

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

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

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.

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

port: A connection point for one or more conductors or fibers.

post-tensioned concrete: A type of reinforced concrete construction in which the embedded steel members are first put under tension, the concrete poured and allowed to harden, and the tension of the steel members released causing compression of the concrete.

post-tension floor: A floor that is constructed of post-tensioned concrete.

private branch exchange: A private telecommunications switching system.

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

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

radio frequency interference: Electromagnetic interference within the frequency band for radio transmission.

return loss: A ratio expressed in dB of the power of the outgoing signal to the power of the reflected signal.

screen: An element of a cable formed by a shield.

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

sheath: See **cable sheath**.

shield: 1) A metallic layer placed around a conductor or group of conductors. 2) The cylindrical outer conductor with the same axis as the center conductor that together form a coaxial transmission line.

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

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

splice: A joining of conductors, meant to be permanent.

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

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 point: See **entrance point (telecommunications)**.

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

telecommunications equipment room: See **equipment room (telecommunications)**.

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

telecommunications media: See **media (telecommunications)**.

telecommunications room: An enclosed architectural space for housing telecommunications equipment, cable terminations, or cross-connect cabling.

telecommunications space: See **space (telecommunications)**.

termination block: A connecting hardware system that facilitates cable termination and cabling administration using jumpers.

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

uninterruptible power supply: A buffer between utility power or other power source and a load that requires continuous precise power.

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 free space to transport information.

zone distribution area: A space in a data center where an equipment outlet or a consolidation point is located.

3.3 Acronyms and abbreviations

AHJ	authority having jurisdiction
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BNC	bayonet Neill-Concelman
CCTV	closed-circuit television
CER	common equipment room
CP	consolidation point
CPU	central processing unit
CSA	Canadian Standards Association International
DSX	digital signal cross-connect
ECA	Electronic Components Association
EDA	equipment distribution area
EIA	Electronic Industries Alliance (Note: ceased operation December 31, 2010. EIA standards are managed by ECA)
EMI	electromagnetic interference
EMS	energy management system
ENI	external network interface
EO	equipment outlet
HC	horizontal cross-connect
HDA	horizontal distribution area
HVAC	heating, ventilation and air conditioning
IC	intermediate cross-connect
IDA	intermediate distribution area
IDC	insulation displacement contact
KVM	keyboard, video, mouse
LAN	local area network
LFMC	liquidtight flexible metallic conduit

LFNC	liquidtight flexible non-metallic conduit
MC	main cross-connect
MDA	main distribution area
NEC®	National Electrical Code®
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
PBX	private branch exchange
PDU	power distribution unit
RFI	radio frequency interference
SAN	storage area network
SDH	synchronous digital hierarchy
SONET	synchronous optical network
STM	synchronous transport model
TIA	Telecommunications Industry Association
TNC	threaded Neill-Concelman
TR	telecommunications room
UL	Underwriters Laboratories Inc
UPS	uninterruptible power supply
WAN	wide area network
ZDA	zone distribution area

3.4 Units of measure

A	ampere
dB	decibel
°C	degrees Celsius
°F	degrees Fahrenheit
ft	feet, foot
in	inch
kb/s	kilobit per second
km	kilometer
kPa	kilopascal
kVA	kilovoltamp
kW	kilowatt
lbf	pound-force
m	meter
MHz	megahertz
mm	millimeter

nm	nanometer
μm	micrometer (micron)

4 DATA CENTER DESIGN OVERVIEW

4.1 General

The following information and recommendations are intended to enable an effective implementation of a data center design by identifying the appropriate actions to be taken in each step of the planning and design process. The design specific details are provided in the subsequent clauses and annexes.

The steps in the design process described below apply to the design of a new data center or the expansion of an existing data center. It is essential for either case that the design of the telecommunications cabling system, equipment floor plan, electrical plans, architectural plan, HVAC, security, and lighting systems be coordinated. Ideally, the process should be:

a) Estimate equipment telecommunications, space, power, and cooling requirements of the data center at full capacity. Anticipate future telecommunications, power, and cooling trends over the lifetime of the data center.

b) Provide space, power, cooling, security, floor loading, grounding, electrical protection, and other facility requirements to architects and engineers. Provide requirements for operations center, loading dock, storage room, staging areas and other support areas.

c) Coordinate preliminary data center space plans from architect and engineers. Suggest changes as required.

d) Create an equipment floor plan including placement of major rooms and spaces for entrance rooms, main distribution areas, intermediate distribution areas, horizontal distribution areas, zone distribution areas and equipment distribution areas. Provide expected power, cooling, and floor loading requirements for equipment to engineers. Provide requirements for telecommunications pathways.

e) Obtain an updated plan from engineers with telecommunications pathways, electrical equipment, and mechanical equipment added to the data center floor plan at full capacity.

f) Design telecommunications cabling system based on the needs of the existing and planned future equipment to be located in the data center.

The data center shall meet the requirements of the AHJ and should follow NFPA 75.

4.2 Relationship of data center spaces to other building spaces

Figure 2 illustrates the major spaces of a typical data center and how they relate to each other and the spaces outside of the data center. See clause 6 for information concerning the telecommunications spaces within the data center.

This Standard addresses telecommunications infrastructure for the data center spaces, which is the computer room and its associated support spaces.

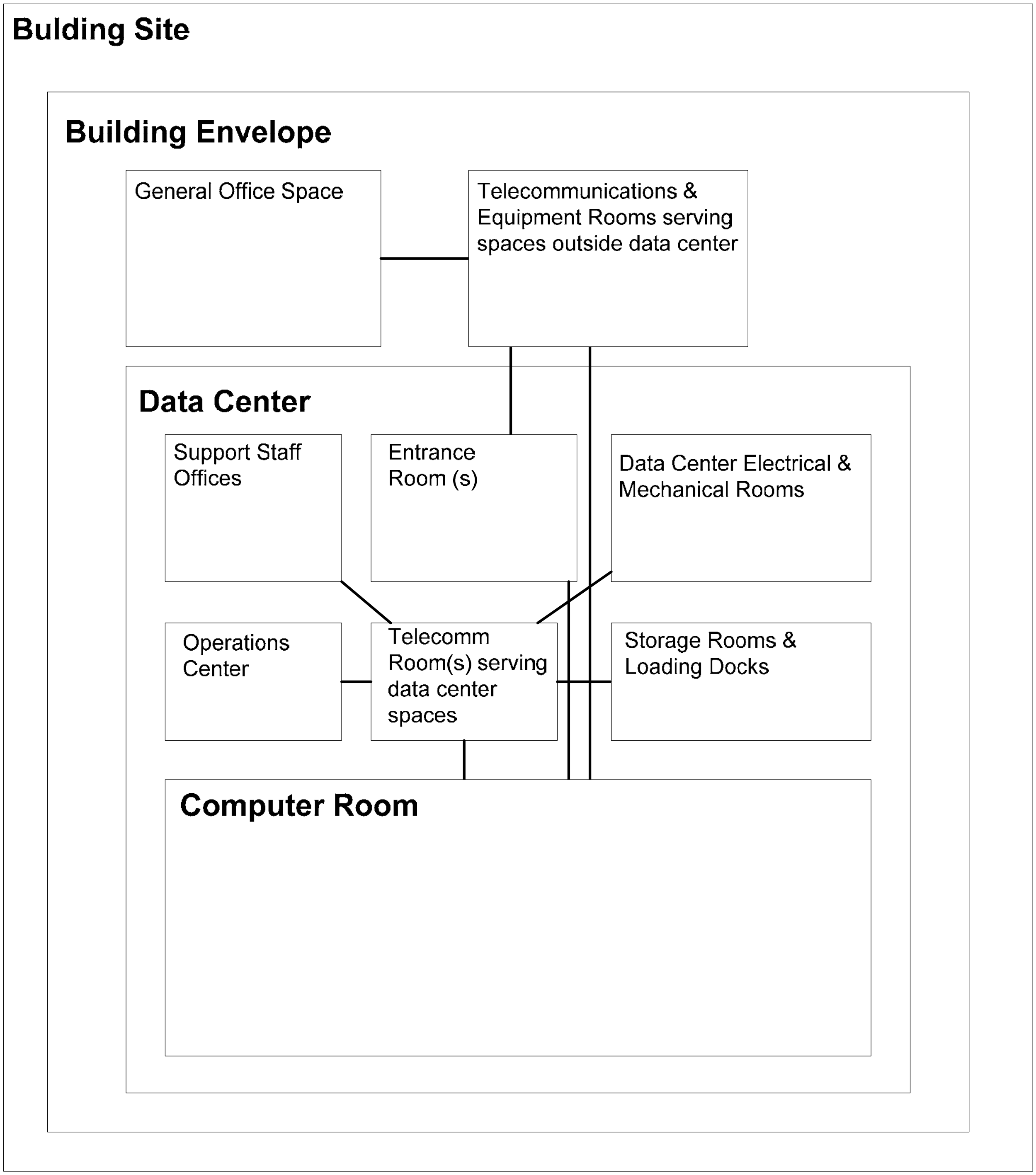


Figure 2: Relationship of spaces in a data center

4.3 Tiering

This Standard includes information for four tiers relating to various levels of availability and security of the data center facility infrastructure. Higher tiers correspond to higher availability and security. Annex F of this Standard provides detailed information for each of the four tiers.

It is important to understand that certain intentional or accidental events, or acts of nature, pose a risk to the operation of data centers. It is important for the data center designer, administrator and manager to both assess and try to mitigate the risk to their facilities these events pose, as well as make contingency plans. The designer should provide a risk assessment, as well as ways to mitigate that risk. Risk mitigation can take many forms including:

a) a risk model to demonstrate the event probability based on industry accepted models (e.g., earthquake or lightning);
b) risk avoidance (separation, protection, security, etc.);
c) resiliency and redundancy, at both a systems and facilities level; and
d) replicating applications and data between data centers.

4.4 Consideration for involvement of professionals

Data centers are designed to support the requirements of large quantities of computer and telecommunications equipment. Therefore, telecommunications and information technology professionals and specifications should be involved in the design of the data center from its inception. In addition to the space, environmental, adjacency, and operational requirements for the computer and telecommunications equipment, data center designs need to address the requirements of the telecommunications pathways and spaces specified in this Standard.

5 DATA CENTER CABLING SYSTEM INFRASTRUCTURE

This Standard establishes a structure for data center cabling system based on the generic cabling system structure in ANSI/TIA-568-C.0.

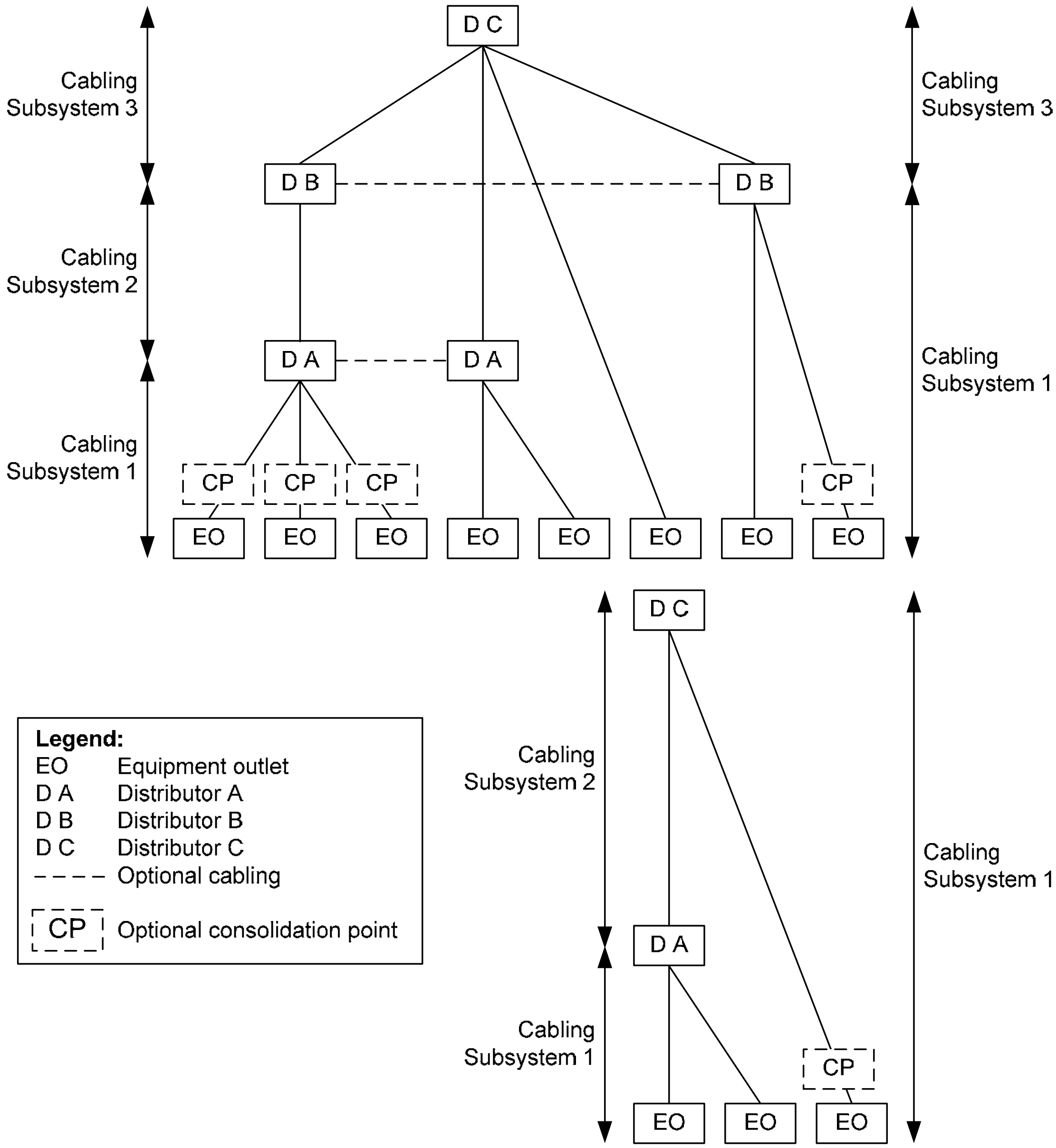


Figure 3: Elements of generic cabling topology

Figure 3 above provides a representation of the functional elements that comprise a generic cabling system. Figure 4 below illustrates a representative model for the various functional elements that comprise a cabling system for a data center. It depicts the relationship between the elements and how they are configured to create the total system.

The basic elements of the data center cabling system structure are the following:

a) Horizontal cabling (Cabling Subsystem 1 – see clause 7.3)

b) Backbone cabling (Cabling Subsystem 2 and Cabling Subsystem 3 – see clause 7.4)

c) Cross-connect in the entrance room or main distribution area (Distributor C, Distributor B or Distributor A)

d) Main cross-connect (MC) in the main distribution area (Distributor C or could also be Distributor B or Distributor A)

e) Optional intermediate cross-connect (IC) in the intermediate distribution area or main distribution area

f) Horizontal cross-connect (HC) in the telecommunications room, horizontal distribution area or main distribution area (Distributor A or could also be Distributor B or Distributor C)

g) Consolidation point in the zone distribution area (optional)

h) Equipment outlet (EO) located in the equipment distribution area or zone distribution area

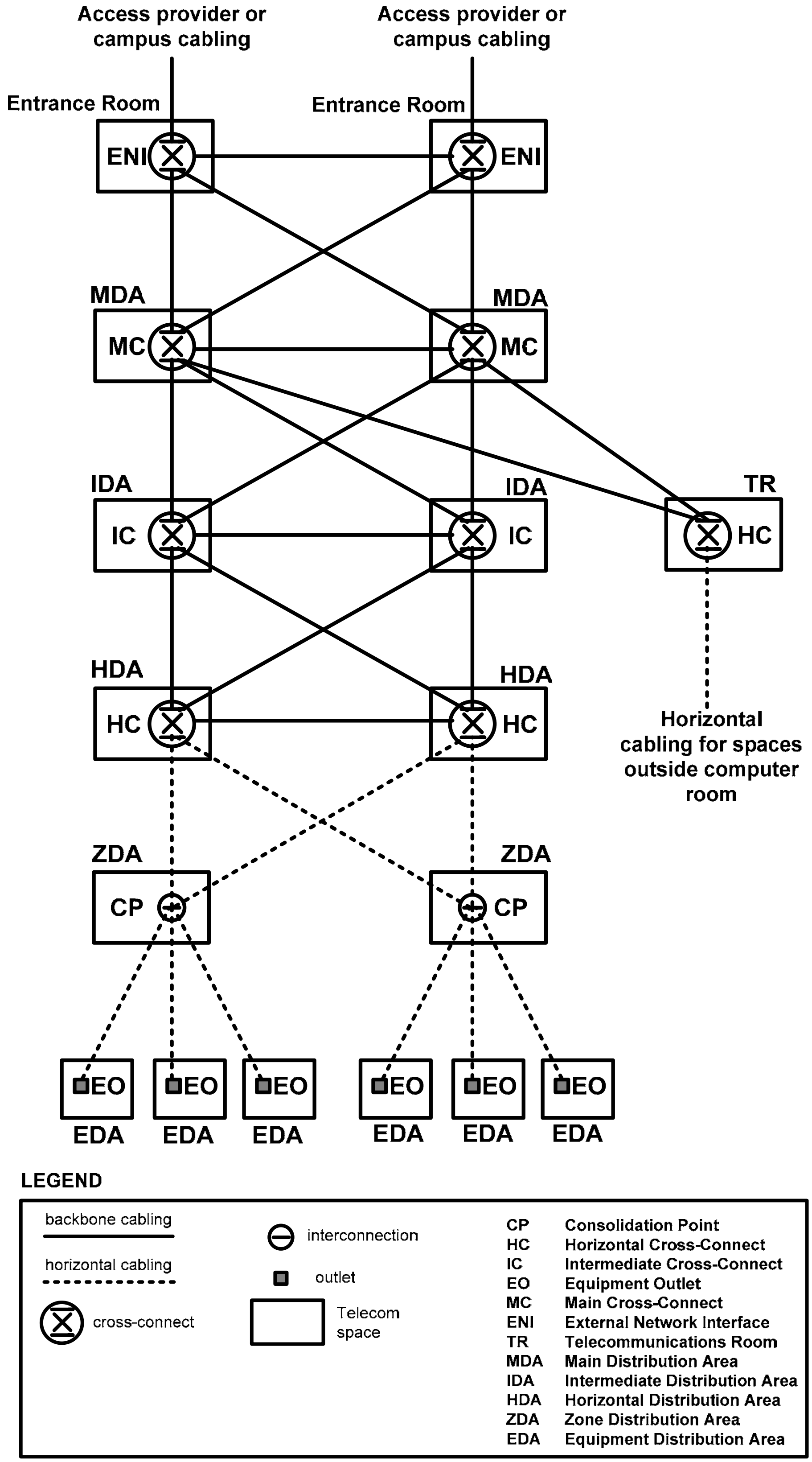


Figure 4: Example of a typical data center topology

6 DATA CENTER TELECOMMUNICATIONS SPACES AND RELATED TOPOLOGIES

6.1 General

The data center requires spaces dedicated to supporting the telecommunications infrastructure. Telecommunications spaces shall be dedicated to support telecommunications cabling and equipment. Typical spaces found within a data center generally include the entrance room, main distribution area (MDA), intermediate distribution area (IDA), horizontal distribution area (HDA), zone distribution area (ZDA) and equipment distribution area (EDA). With the exception of the MDA and EDA, not all of these spaces may be present within the data center. These spaces shall be sized to accommodate the anticipated end-state size and demand forecast for all data center phases. These spaces should also be planned to provide for growth and transition to evolving technologies. These spaces may or may not be walled off or otherwise separated from the other computer room spaces.

6.2 Data center structure

6.2.1 Major elements

The data center telecommunications spaces include the entrance room, main distribution area (MDA), intermediate distribution area (IDA), horizontal distribution area (HDA), zone distribution area (ZDA) and equipment distribution area (EDA).

The entrance room is the space used for the interface between data center structured cabling system and inter-building cabling, both access provider and customer-owned. This space includes the access provider demarcation hardware and access provider equipment. The entrance room may be located outside the computer room if the data center is in a building that includes general purpose offices or other types of spaces outside the data center. The entrance room may also be outside the computer room for improved security, as it avoids the need for access provider technicians to enter the computer room. Data centers may have multiple entrance rooms to provide additional redundancy or to avoid exceeding maximum cable lengths for access provider-provisioned circuits.

The entrance room interfaces with the computer room through the MDA. In some cases, the secondary entrance rooms may have cabling to IDAs or HDAs to avoid exceeding maximum cable lengths for access provider-provisioned circuits. The entrance room may be adjacent to or combined with the MDA.

The MDA includes the main cross-connect (MC), which is the central point of distribution for the data center structured cabling system and may include a horizontal cross-connect (HC) when equipment areas are served directly from the MDA. The MDA may also support an intermediate cross-connect (IC). This space is inside the computer room; it may be located in a dedicated room in a multi-tenant data center for security. Every data center shall have at least one MDA. The computer room core routers, core LAN switches and core SAN switches are often located in the MDA, because this space is the hub of the cabling infrastructure for the data center. Access provider provisioning equipment (for example the M13 multiplexers) is often located in the MDA rather than in the entrance room to avoid the need for a second entrance room due to circuit length restrictions.

The MDA may serve one or more IDAs, HDAs, and EDAs within the data center and one or more telecommunications rooms located outside the computer room space to support office spaces, operations center and other external support rooms.

The IDA may serve one or more HDAs and EDAs within the data center, and one or more telecommunications rooms located outside the computer room space.

The HDA is used to serve the EDAs when the HC is not located in the MDA or an IDA. Therefore, when used, the HDA may include the HC, which is the distributor for cabling to the EDAs. The HDA is inside the computer room, but may be located in a dedicated room within the computer room for additional security. The HDA typically includes LAN switches, SAN switches, and Keyboard/Video/Mouse (KVM) switches for the end equipment located in the EDAs. A data center may have computer room spaces located on multiple floors with each floor being serviced by its own HC. Some data centers may require no HDAs, as the entire computer room may be able to be supported from the MDA. However, a typical data center will have several HDAs.

The EDA is the space allocated for end equipment, including computer systems and telecommunications equipment (e.g., servers, mainframe, and storage arrays). These areas shall not serve the purposes of an entrance room, MDA or HDA.

There may be an optional interconnection within a ZDA that is called a consolidation point (see figure 4). This consolidation point is between the horizontal cross-connect and the equipment outlet to facilitate moves, adds, and changes.

6.2.2 Basic data center topology

The basic data center includes a single entrance room, possibly one or more telecommunications rooms, one MDA, and several HDAs. Figure 5 illustrates the basic data center topology.

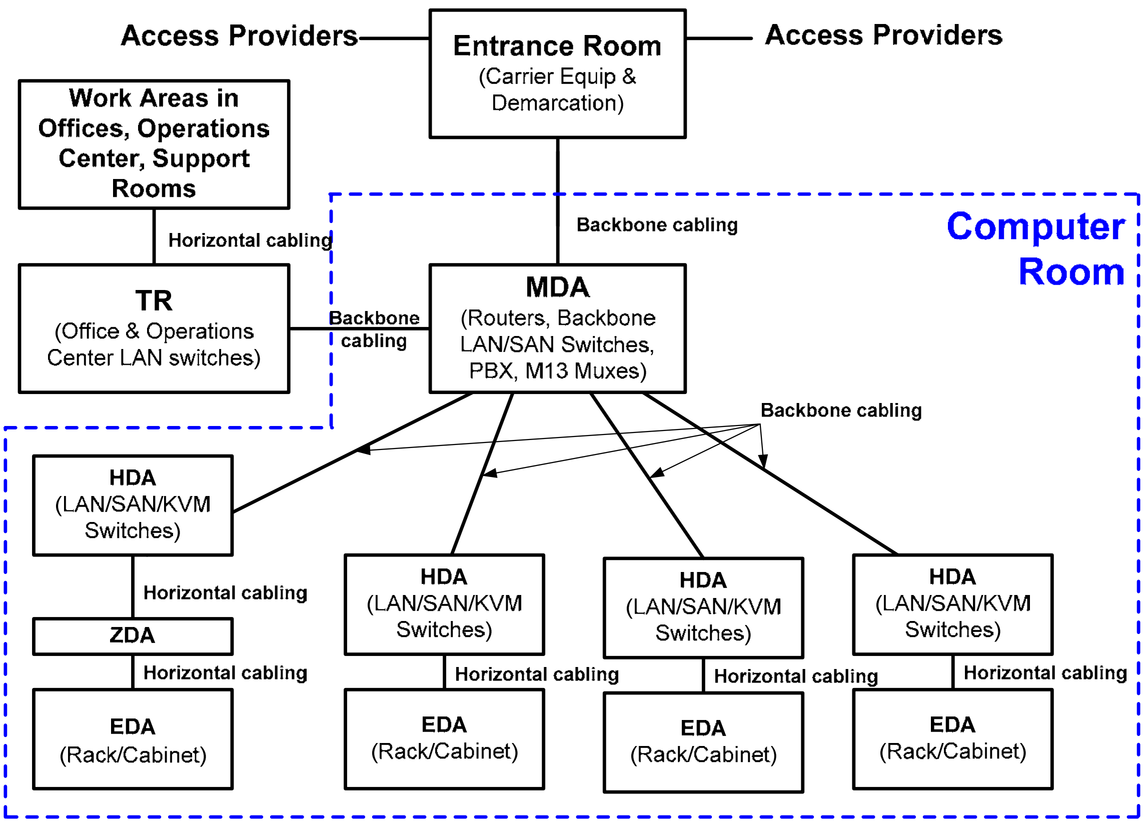


Figure 5: Example of a basic data center topology

6.2.3 Reduced data center topologies

Data center designers can consolidate the main cross-connect, and horizontal cross-connect in a single MDA, possibly as small as a single cabinet or rack. The telecommunications room for cabling to the support areas and the entrance room may also be consolidated into the MDA in a reduced data center topology. The reduced data center topology is illustrated in figure 6.

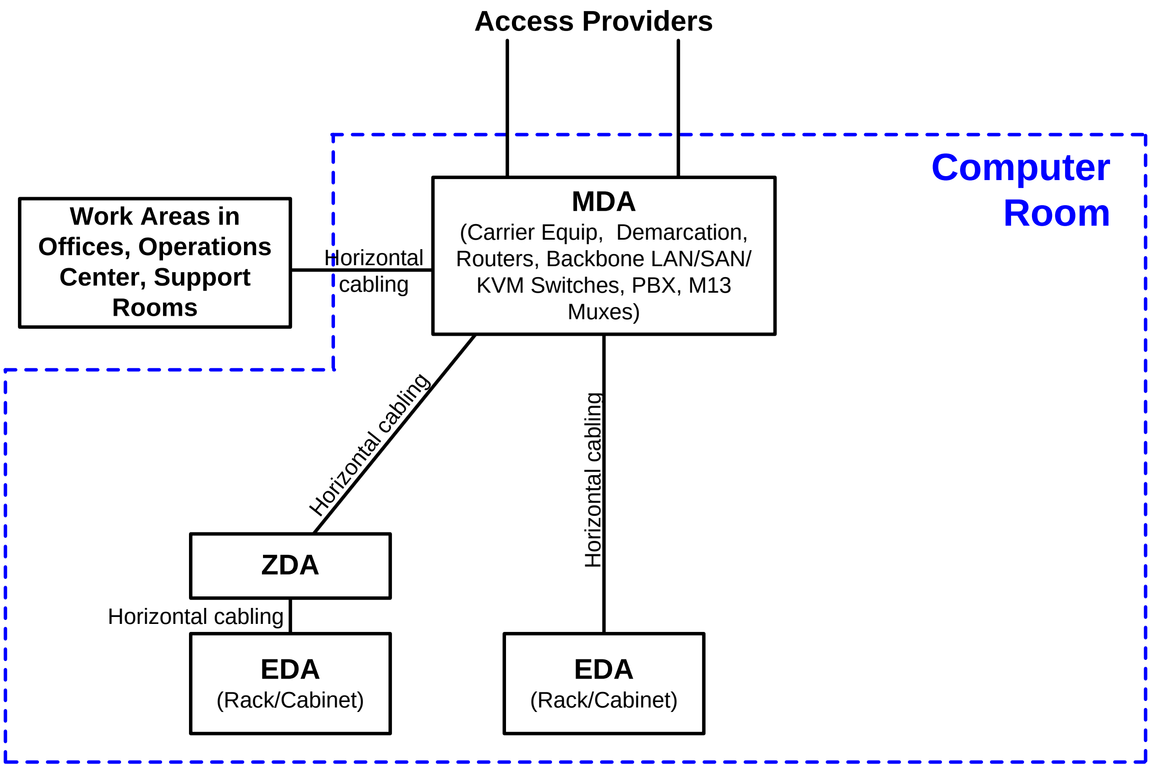


Figure 6: Example of a reduced data center topology

6.2.4 Distributed data center topologies

Large data centers, such as data centers located on multiple floors or in multiple rooms, may require intermediate cross-connects located in IDAs. Each room or floor may have one or more IDAs.

Multiple telecommunications rooms may be required for data centers with large or widely separated office and support areas.

Circuit length restrictions may require multiple entrance rooms for very large data centers. The data center topology with multiple entrance rooms and IDAs is shown in Figure 7. The primary entrance room shall not have direct connections to IDAs and HDAs. Although cabling from the secondary entrance room directly to the IDAs and HDAs is not common practice or encouraged, it is allowed to meet certain circuit length limitations and redundancy needs.

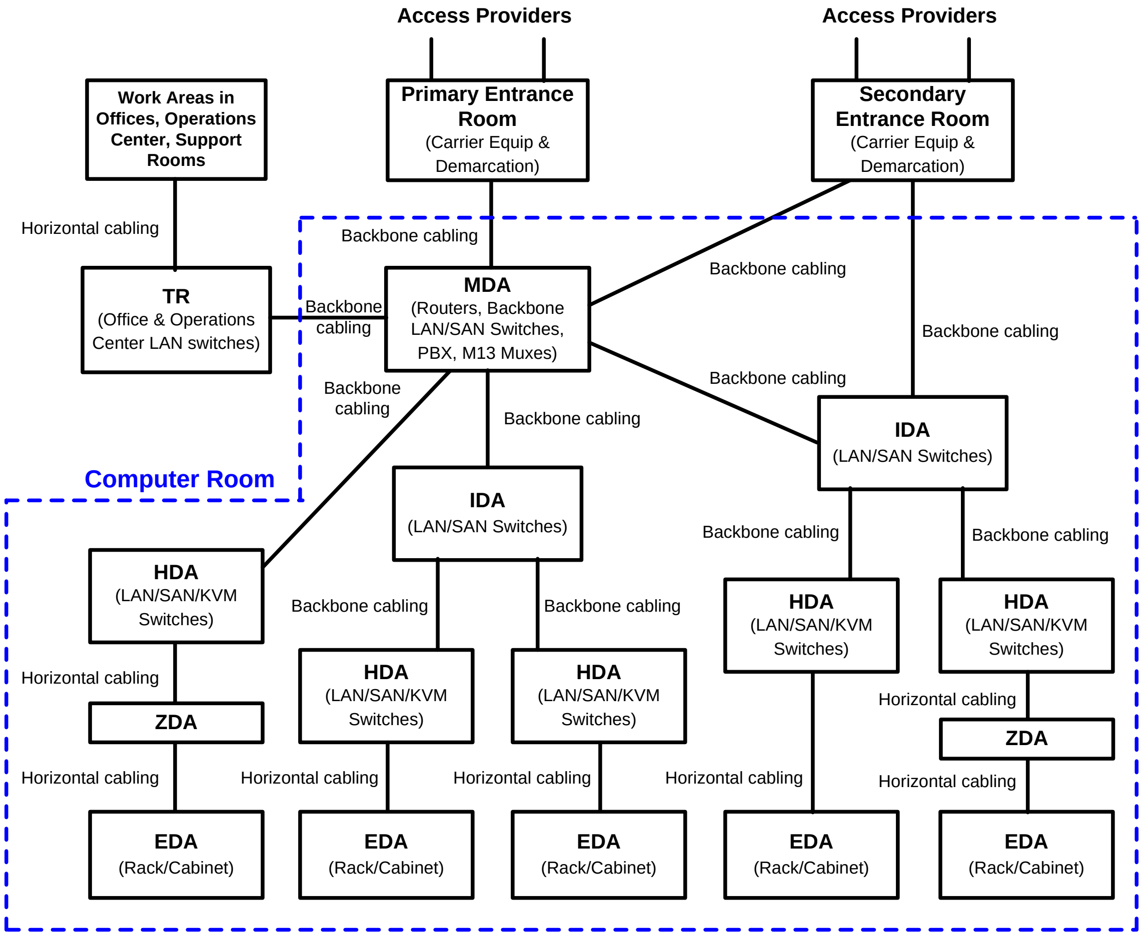


Figure 7: Example of a distributed data center topology with multiple entrance rooms

6.3 Energy efficient design

6.3.1 General

Energy efficiency should be considered in the design of the data center. The following clauses provide recommendations for design of telecommunications cabling, pathways, and spaces that can improve energy efficiency. Other methods involving other aspects of the data center design are described in other publications, including the following documents:

- ASHRAE, Best Practices for Datacom Facility Energy Efficiency, Second Edition (2009);
- ASHRAE, Design Considerations for Data and Communications Equipment Centers, Second Edition (2009);
- ASHRAE 2011 Thermal Guidelines for Data Processing Environments – Expanded Data Center Classes and Usage Guidance, 2011;
- European Union, Best Practices for EU Code of Conduct on Data Centres, Version 3.0 (2011);
- European Union, Code of Conduct on Data Centres Energy Efficiency, Version 2.0 (2010).

6.3.2 Energy efficiency recommendations

6.3.2.1 General

By their nature, data centers consume large amounts of energy, most of which is converted to heat, requiring serious consideration to cooling efficiencies. There is no single thermal management architecture that is most energy efficient for all installations. Critical factors unique to the customer, application, and environment should be carefully evaluated in the start-up analysis along with operational analysis.

6.3.2.2 Telecommunications cabling

Overhead telecommunications cabling may improve cooling efficiency and is a best practice where ceiling heights permit because it can substantially reduce airflow losses due to airflow obstruction and turbulence caused by under floor cabling and cabling pathways. See ANSI/TIA-569-C for additional guidance regarding overhead pathways (e.g. structural load).

If telecommunications cabling is installed in an under floor space that is also used for cooling, under floor air obstructions can be reduced by:

- using network and cabling designs that minimize the need for under floor cabling;
- selecting cables with smaller diameters to minimize the volume of under floor cabling;
- designing the cabling pathways to minimize adverse impact on under floor airflow (e.g., routing cabling in hot aisles rather than cold aisles);
- designing the cabling layout such that the cabling routes are opposite to the direction of air flow so that at the origin of airflow there is the minimal amount of cabling to impede flow (see figure 8 for examples); and
- properly sizing pathways and spaces to accommodate cables with minimal obstruction (e.g. shallower and wider trays).

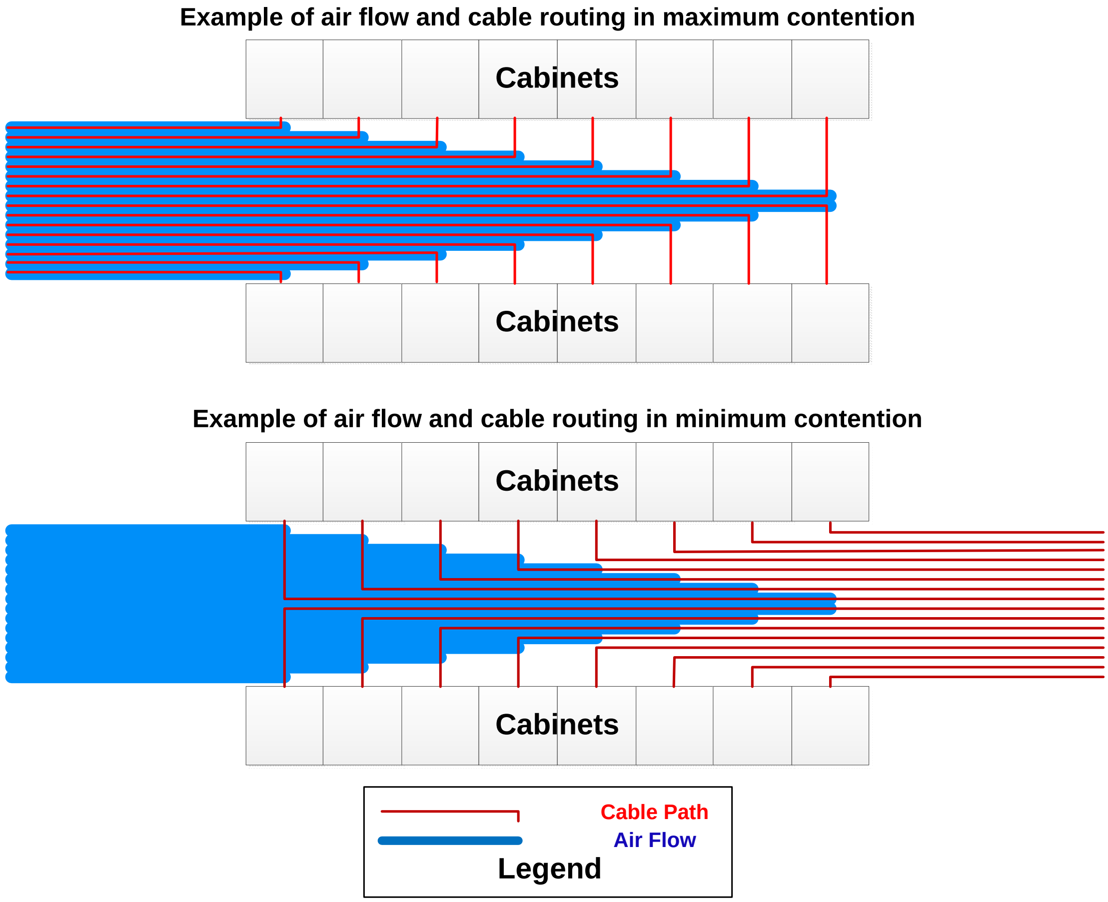


Figure 8: Examples of routing cables and air flow contention

Routing of telecommunications cabling within cabinets, racks, and other enclosure systems should not hamper the proper cooling of the equipment within the enclosures (e.g., avoid routing of cabling in front of vents). Sufficient airflow as required by the equipment manufacturer shall be maintained.

In all cases, change management procedures should be in place and should include the removal of abandoned cable in accordance with *NEC®*. This assures pathways remain neat so as to not create a weight issue overhead or air dams in under floor systems.

6.3.2.3 Telecommunications pathways

Telecommunications pathways should be placed in such a manner as to minimize disruption to airflow to and from equipment. For example, if placed under the access floor they should not be placed under ventilated tiles or where they disrupt the flow of air into or out of air conditioning equipment.

Consider computational fluid dynamics (CFD) models for large data centers to optimize location of telecommunications pathways, air conditioning equipment, equipment enclosures, air return, air vents, and ventilated tiles.

6.3.2.4 Telecommunications spaces

Consider use of enclosures or enclosure systems that improve cooling efficiency:

- cabinets with isolated air-supply;
- cabinets with isolated air-return;
- cabinets with in-cabinet cooling systems;

- hot-aisle containment or cold-aisle containment systems; and
- cabinets that minimize air bypass through the space between equipment rails and cabinet sides.

Routing of cabling and cable pathways should not compromise the efficiency of the enclosure or enclosure system. For example, cable openings in the enclosure or enclosure system should use brushes or grommets to minimize loss of air.

Blanking panels should be used in unused rack unit positions in equipment cabinets to avoid mixing of hot and cold air. Unused cabinet/rack positions in equipment rows should be filled with a cabinet/rack or otherwise sealed to prevent mixing of air in hot- and cold-aisles.

Equipment with different environmental requirements should be segregated into different spaces to allow equipment with less restrictive environmental requirements to be operated in spaces in a more energy-efficient environment.

Consider allocating and designing separate spaces dedicated to high density equipment so that the entire data center is not powered and cooled for the equipment with the greatest energy demands. It is recommended to use a cooling system that is able to vary the volume of air as needed.

Equipment should match the airflow design for the enclosures and computer room space in which they are placed. This generally means that equipment should be mounted in cabinets/racks with air intakes facing the cold-aisle and air exhausts facing the hot-aisle. Equipment with non-standard airflow may require specially designed enclosures to avoid disruption of proper air flow.

Provision cabinets and racks with power strips that permit monitoring of power levels to ensure that power levels in enclosures do not exceed designed power and cooling levels.

Use energy efficient lighting and lighting schemes (see 6.4.4.4).

Avoid exterior windows and sky lights in computer rooms and other environmentally controlled telecommunications spaces.

Consider operation and design practices that minimize the need to cooling unneeded equipment and spaces.

- Build the computer room in phases or zones, only building and occupying spaces as needed.
- In occupied data centers, institute a process to identify and remove equipment that is no longer needed or to identify and consolidate (e.g., virtualize) underutilized equipment.
- Install monitoring equipment and perform periodic reporting of total data center energy use and energy use of individual systems such as power distribution units, air conditioning units, and IT equipment cabinets/racks.
- Consider air baffles and temporary room dividers that can be moved and adjusted as needed.

6.4 Computer room requirements

6.4.1 General

The computer room is an environmentally controlled space that serves the sole purpose of supporting equipment and cabling directly related to the computer systems and other telecommunications systems.

The computer room shall meet the requirements for distributor rooms in ANSI/TIA-569-C with additional requirements, exceptions and allowances as specified in 6.4.

The floor layout should be consistent with equipment and facility providers' requirements, such as:

- floor loading requirements including equipment, cables, patch cords, and media (static concentrated load, static uniform floor load, dynamic rolling load);

- service clearance requirements (clearance requirements on each side of the equipment required for adequate servicing of the equipment);
- air flow requirements;
- mounting requirements;
- power requirements and DC circuit length restrictions; and
- equipment connectivity length requirements (for example, maximum channel lengths to peripherals and consoles).

6.4.2 Location

When selecting the computer room site, avoid locations that are restricted by building components that limit expansion such as elevators, building core, outside walls, or other fixed building walls. Accessibility for the delivery of large equipment to the equipment room should be provided (see ANSI/TIA-569-C).

The location of the computer room should be a $M_1I_1C_1E_1$ environment (ANSI/TIA-568-C.0). Alternatively, the computer room should be designed to create an environment compatible with $M_1I_1C_1E_1$ classifications. The computer room should not have exterior windows, as exterior windows increase heat load and reduce security.

6.4.3 Access

Computer room doors should provide access to authorized personnel only. Additionally, access to the room shall comply with the requirements of the AHJ. For additional information on monitoring computer room access, see annex F.

6.4.4 Architectural design

6.4.4.1 Size

The computer room shall be sized to meet the known requirements of specific equipment including proper clearances; this information can be obtained from the equipment provider(s). Sizing should include projected future as well as present requirements. See annex D regarding space considerations related to computer rooms.

6.4.4.2 Guidelines for other equipment

Any UPS containing flooded-cell batteries should be located in a separate room except as required by the AHJ.

6.4.4.3 Ceiling height

The minimum height in the computer room shall be 2.6 m (8.5 ft) from the finished floor to any obstruction such as sprinklers, lighting fixtures, overhead cable tray or cameras. Cooling requirements or racks/cabinets taller than 2.13 m (7 ft) may dictate higher ceiling heights. A minimum of 460 mm (18 in) clearance shall be maintained from water sprinkler heads.

6.4.4.4 Lighting

Lighting fixtures should be located above aisles between cabinets rather than directly above cabinets or overhead cable pathway systems.

Emergency lighting and signs shall be properly placed per authority having jurisdiction (AHJ) such that an absence of primary lighting will not hamper emergency exit.

It is recommended that a three-level lighting protocol be used in data centers depending on human occupancy:

- **Level 1:** data center unoccupied - lighting should be sufficient to allow effective use of video surveillance equipment.
- **Level 2:** initial entry into the data center - motion sensors should be used to activate lights in the immediate area of entry and be programmed to illuminate aisles and passageways.

Sufficient lighting should be provided to allow safe passage through the space and to permit identification via security cameras.

- **Level 3:** occupied space - when the data center is occupied for purposes of maintenance or interaction with equipment, lighting shall be 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. In data centers larger than 230 m^2 (2500 ft^2) zone lighting is recommended that provides Level 3 in the immediate area of work and Level 2 in all other zones.
- **Optional override**: lighting in all zones at level 3.

To allow improved energy efficiency and control, energy efficient lighting (e.g., LED) should be considered as an option to implement the three-level lighting protocol, depending on human occupancy and function in data centers.

6.4.4.5 Doors

Doors shall be a minimum of 1 m (3 ft) wide and 2.13 m (7 ft) high, without doorsills, hinged to open outward (code permitting), slide side-to-side, or be removable. Doors shall be fitted with locks and have either no center posts or removable center posts to facilitate access for large equipment. Exit requirements for the computer room shall meet the requirements of the AHJ.

6.4.4.6 Floor loading

A structural engineer shall be consulted during the design to specify the floor loading limit. The minimum distributed floor loading capacity shall be 7.2 kPA (150 lbf/ ft^2). The recommended distributed floor loading capacity is 12 kPA (250 lbf/ ft^2). Floors should be appropriately reinforced if equipment exceeding these specifications is anticipated. This requirement also applies in the case of relocation of equipment at a later time. If extensive relocation is anticipated, the entire floor should be appropriately reinforced.

The floor shall also have a minimum of 1.2 kPA (25 lbf/ ft^2) hanging capacity for supporting loads that are suspended from the bottom of the floor (for example, cable ladders suspended from the ceiling of the floor below). The recommended hanging capacity of the floor is 2.4 kPA (50 lbf/ ft^2). Refer to Telcordia specification GR-63-CORE regarding floor loading capacity measurement and test methods.

6.4.4.7 Uninterruptable power notification

Entrance doors into a room where equipment is powered by uninterruptable power systems should bear the following warning on the exterior side of the door:

> “WARNING – Uninterruptible power is present in this area. Power will be present at equipment even in the event of a total building shutdown at the main service disconnect.”

The sign should be red laminate with white engraved letters that are 50 mm (2 in) minimum in height.

6.4.4.8 Signage

Signage should be developed within the security plan of the building.

6.4.4.9 Seismic considerations

Specifications for related facilities shall accommodate the applicable seismic zone requirements. Refer to Telcordia specification GR-63-CORE for more information regarding seismic considerations.

6.4.5 Environmental design

6.4.5.1 Contaminants

The operating computer room environment shall conform to a C_1 environmental conditions as defined in ANSI/TIA-568-C.0. Common methods for achieving C_1 classification include vapor barriers, positive room pressure, or absolute filtration.

6.4.5.2 HVAC
If the computer room does not have a dedicated HVAC system, the computer room shall be located with ready access to the main HVAC delivery system. A computer room is typically not recognized as such by the AHJ unless it has a dedicated HVAC, or utilizes the main building HVAC and has automatic dampers installed.

6.4.5.2.1 Operational parameters

Temperature and humidity in the computer room shall be maintained to meet the requirements for Classes A1 or A2 in ANSI/TIA-569-C.

6.4.5.2.2 Continuous operation

HVAC shall be provided on a 24 hours-per-day, 365 days-per-year basis. If the building system cannot assure continuous operation, a stand-alone unit shall be provided for the computer room.

6.4.5.2.3 Standby operation

The computer room HVAC system should be supported by the computer room standby generator system, if one is installed. If the computer room does not have a dedicated standby generator system, the computer room HVAC should be connected to the building standby generator system, if one is installed.

6.4.5.3 Radio sources
Radio sources (e.g. wireless LAN antennas, cellular telephones, handheld radios, etc.) may interfere with proper operation of the information technology and telecommunications equipment. Consult with the information technology and telecommunications equipment manufacturers regarding the use of or restriction of wireless and radio systems in the computer room.

6.4.5.4 Batteries
If batteries are used for backup, adequate ventilation and spill containment as required shall be provided. Refer to applicable codes and standards (e.g., OSHA CFR 1926.441) for requirements.

6.4.5.5 Vibration
Refer to Telcordia specification GR-63-CORE for more information regarding vibration testing.

6.4.6 Electrical design

6.4.6.1 Power
Separate supply circuits serving the computer room shall be provided and terminated in their own electrical panel or panels.

The computer room shall have duplex convenience outlets (120V 20A) for power tools, cleaning equipment, and equipment not suitable to plug into equipment cabinet power strips. The convenience outlets should not be on the same power distribution units (PDUs) or electrical panels as the electrical circuits used for the telecommunications and computer equipment in the room. The convenience outlets shall be spaced 3.65 m (12 ft) apart along the computer room walls, or closer if specified by local ordinances, and reachable by a 4.5 m (15 ft) cord (per NEC Articles 210 and 645).

6.4.6.2 Standby power
The computer room electrical panels should be supported by the computer room standby generator system, if one is installed. Any generators used should be rated for electronic loads. Generators of this capability are often referred to as “Computer Grade”. If the computer room does not have a dedicated standby generator system, the computer room electrical panels should be connected to the building standby generator system, if one is installed. The power shutdown requirements for computer room equipment are mandated by the AHJ and vary by jurisdiction.

6.4.6.3 Bonding and grounding (earthing)
Refer to ANSI/TIA-607-B for bonding and grounding requirements for computer rooms, equipment cabinets, and racks.

6.4.7 Fire protection

The fire protection systems and hand-held fire extinguishers shall comply with NFPA-75. Sprinkler systems in computer rooms should be pre-action systems.

6.4.8 Water infiltration

Where risk of water ingress exists, a means of evacuating water from the space shall be provided (e.g. a floor drain). Additionally, at least one drain or other means for evacuating water for each 100 m^2 (1000 ft^2) area should be provided. Any water and drain pipes that run through the room should be located away from and not directly above equipment in the room.

Any floor drains below ground level shall be equipped with a backflow prevention device. The use of backflow prevention devices and leak detectors is recommended for all floor drains.

6.5 Entrance room requirements

6.5.1 General

The entrance room is a space, preferably a room, in which access provider-owned facilities interface with the data center cabling system. It typically houses telecommunications access provider equipment and is the location where access providers typically hand off circuits to the customer. This hand-off point is called the demarcation point. It is where the telecommunications access provider’s responsibility for the circuit typically ends and the customer’s responsibility for the circuit begins.

The entrance room will house entrance pathways, protector blocks for balanced twisted-pair entrance cables, termination equipment for access provider cables, access provider equipment, and termination equipment for cabling to the computer room.

6.5.2 Location

The entrance room should be located to ensure that maximum circuit lengths from the access provider demarcation points to the end equipment are not exceeded. The maximum circuit lengths need to include the entire cable route, including patch cords and changes in height between floors and within racks or cabinets. Annex A provides specific circuit lengths (from demarcation point to end equipment) to consider when planning entrance room locations.

> NOTE: Repeaters can be used to extend circuits beyond the lengths specified in annex A.

The entrance rooms may either be located inside or outside the computer room space. Security concerns may dictate that the entrance rooms are located outside the computer room to avoid the need for access provider technicians to access the computer room. However, in larger data centers, circuit length concerns may require that the entrance room be located in the computer room.

The location of the entrance room should be a $M_1I_1C_1E_1$ environment (ANSI/TIA-568-C.0). Alternatively, the entrance room should be designed to create an environment compatible with $M_1I_1C_1E_1$ classifications.

Cabling in the entrance rooms should use the same cable distribution (overhead or under floor) as used in the computer room; this will minimize cable lengths as it avoids a transition from overhead cable trays to under floor cable trays.

6.5.3 Quantity

Large data centers may require multiple entrance rooms to support some circuit types throughout the computer room space and/or to provide additional redundancy.

The additional entrance rooms may have their own entrance pathways for dedicated service feeds from the access providers. Alternatively, the additional entrance rooms may be subsidiaries of the primary entrance room, in which case the access provider service feeds come from the primary entrance room.

6.5.4 Entrance conduit routing under access floor

If the entrance room is located in the computer room space, the entrance conduit runs should be designed to avoid interfering with airflow, chilled water piping and other cable routing under the access floor.

6.5.5 Access provider and service provider spaces

Access provider and service provider spaces for data centers are typically located either in the entrance room or in the computer room. Refer to ANSI/TIA-569-C for information on access provider and service provider spaces.

The access provider and service provider spaces in single user data center entrance rooms typically do not require partitions because access to the data center entrance rooms is carefully controlled. Access and service providers that lease space in the computer room typically require secure access to their spaces.

6.5.6 Building entrance terminal

Outside terminals are typically used when the entrance connection is located in a closure on an outside wall of a building. Inside terminals are used when the outside cable will be connected to the inside distribution cabling system. Refer to ANSI/TIA-568-C.0, ANSI/TIA-569-C and ANSI/TIA-758-B for additional information on entrance facilities and entrance facility connections.

6.5.7 Architectural design

6.5.7.1 General

The decision of a room or open area is provided should be based on security (with consideration to both access and incidental contact), the need for wall space for protectors, entrance room size, and physical location.

6.5.7.2 Size

The entrance room shall be sized to meet known and projected maximum requirements for:

- backboard and frame space for termination of access provider and campus cabling;
- access provider racks;
- customer-owned equipment to be located in the entrance room;
- demarcation racks including termination hardware for cabling to the computer room;
- pathways.

The space required is related more closely to the number of access providers, number of circuits, and type of circuits to be terminated in the room than to the size of the data center. Meet with all access providers to determine their initial and future space requirements. See annex B for more information regarding access provider coordination and access provider demarcation.

Space should also be provided for campus cabling. Cables containing metallic components, including optical fiber cables with metallic components, shall be terminated with protectors in the entrance room. The protectors may either be wall-mounted or frame-mounted. The space for protectors shall be located as close as practical to the point of entrance of the cables into the building. Optical fiber campus cables may be terminated in the main cross-connect instead of the entrance room if they have no metallic components (for example, cable sheath or strength member). Refer to applicable codes regarding entrance cable and entrance cable termination requirements.

6.5.7.3 Plywood backboards

Where wall terminations are to be provided for protectors, one wall shall be covered with 19 mm (3/4 inch) plywood. The backboard shall be 1.2 m (4 ft) x 2.4 m (8 ft) sheets, mounted vertically, and with the bottom of the plywood mounted 150 mm (6 in) AFF with the best side toward the room. Plywood shall be A/C grade and finished with two coats of white 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.

6.5.7.4 Ceiling height

The minimum height shall meet the requirements of 6.4.4.3.

6.5.7.5 Lighting

Lighting shall meet the requirements of 6.4.4.4.

6.5.7.6 Doors

Doors shall meet the requirements of 6.4.4.5.

6.5.7.7 Signage

Signage should be developed within the security plan of the building.

6.5.7.8 Seismic considerations

Specifications for seismic considerations shall meet the requirements of 6.4.4.9

6.5.7.9 Environmental design

The environmental design for entrance rooms in regard to contaminants, HVAC, continuous operation, standby operation, operational parameters, radio sources, batteries and vibration, shall meet the requirements of 6.4.5. Consider having dedicated air-conditioning for the entrance room. If the entrance room has dedicated air-conditioning, temperature control circuits for the entrance room air-conditioning units should be powered from the same PDUs or panel boards that serve the entrance room racks. HVAC for the equipment in the entrance room should have the same degree of redundancy and backup as the HVAC and power for the computer room.

6.5.7.10 Electrical design

The electrical design, such as power, standby power and, bonding and grounding (earthing), shall meet the requirement of clause 6.4.6. Consider having dedicated PDUs and UPS fed power panels for the entrance room. The quantity of electrical circuits for entrance rooms depends on the requirements of the equipment to be located in the room. The entrance rooms shall use the same electrical backup systems (UPS and generators) as that used for the computer room. The degree of redundancy for entrance room mechanical and electrical systems shall be the same as that for the computer room.

6.5.8 Fire protection

The fire protection systems and hand-held fire extinguishers shall comply with NFPA-75.
Sprinkler systems in entrance rooms should be pre-action systems.

6.5.9 Water infiltration

Where risk of water ingress exists, a means of evacuating water from the space shall be provided (e.g. a floor drain). Any water and drain pipes that run through the room should be located away from and not directly above equipment in the room.

6.6 Main distribution area

6.6.1 General

The main distribution area (MDA) is the central space where the point of distribution for the structured cabling system in the data center is located. The data center shall have at least one MDA. The core routers and core switches for the data center networks are often located in or near the MDA.

In data centers that are used by multiple organizations, such as disaster recovery data centers, web hosting data centers, and collocation facilities, the MDA should be in a secure space.

6.6.2 Location

The MDA should be centrally located to avoid exceeding maximum length restrictions for the applications to be supported, including maximum cable lengths for access provider circuits served out of the entrance room.

6.6.3 Facility requirements

If the MDA is in an enclosed room, consider a dedicated HVAC, PDU, and UPS fed power panels for this area.

If the MDA has dedicated HVAC, the temperature control circuits for air-conditioning units should be powered and controlled from the same PDUs or power panels that serve the telecommunications equipment in the MDA.

The architectural, mechanical, and electrical requirements for the MDA are the same as that for the computer room.

6.7 Intermediate distribution area

6.7.1 General

The intermediate distribution area (IDA) is the space that supports the intermediate cross-connect. It may be used to provide a second level cabling subsystem (Cabling Subsystem 2) in data centers too large to be accommodated with only Cabling Subsystem 3 (cabling from the MDA) and Cabling Subsystem 1 (cabling from HDAs to EDAs). The IDA is optional and may include active equipment.

In data centers that are used by multiple organizations, such as disaster recovery data centers, web hosting data centers, and collocation facilities, the IDA should be in a secure space.

6.7.2 Location

The IDA should be centrally located to avoid exceeding maximum length restrictions for the applications to be supported, including maximum cable lengths for access provider circuits served out of the entrance room.

6.7.3 Facility requirements

The facility requirements of an IDA are the same as that for an HDA (see 6.8.3).

6.8 Horizontal distribution area

6.8.1 General

The horizontal distribution area (HDA) is the space that supports cabling to the EDAs. The LAN, SAN, console, and KVM switches that support the end equipment are also typically located in the HDA. The MDA may serve as a HDA for nearby equipment or for the entire computer room.

There should be a minimum of one horizontal cross-connect (HC) per floor. The HC may be in a HDA, IDA, or MDA. Additional HDAs may be required to support equipment beyond the horizontal cable length limitation.

The maximum number of connections per HDA should be adjusted based on cable tray capacity, leaving room in the cable trays for future cabling.

In data centers that are used by multiple organizations, such as disaster recovery data centers, web hosting data centers, and collocation facilities, the HDA should be in a secure space.

6.8.2 Location

The HDAs should be located to avoid exceeding maximum backbone lengths from the MDA or IDA and maximum lengths for the media type.

6.8.3 Facility requirements

If the HDA is in an enclosed room, consideration regarding a dedicated HVAC, PDUs, and UPS fed power panels for the HDA should be taken.

Air-conditioning units should be powered from different PDUs or power panels that serve the telecommunications equipment in the HDA.

The architectural, mechanical, and electrical requirements for the HDA are the same as that for the computer room.

6.9 Zone distribution area

Coaxial or twisted-pair connections in a ZDA should be limited to 288 to avoid cable congestion, particularly for enclosures meant to be placed overhead or under 2 ft. x 2 ft. (or 600 mm x 600 mm) access floor tiles.

Cross-connection shall not be used in the ZDA. No more than one ZDA shall be used within the same horizontal cable run.

There shall be no active equipment in the ZDA.

6.10 Equipment distribution areas

The EDAs are spaces allocated for end equipment, including computer systems and communications equipment.

The end equipment is typically floor standing equipment or equipment mounted in cabinets or racks.

Horizontal cables are terminated in EDAs on equipment outlets. Sufficient power receptacles and connecting hardware should be provided for each equipment cabinet and rack to minimize patch cord and power cord lengths.

Point-to-point cabling is permitted between equipment located in the EDA. Cable lengths for point-to-point cabling between equipment in the EDA should be no greater than 15 m (49 ft) and should be between equipment in adjacent racks or cabinets in the same row. Where point to point cabling is used between cabinets, each end of a cable shall be labeled with a permanent label. When point to point cables are no longer used, the cables shall be removed.

6.11 Telecommunications room

In data centers, the telecommunications room (TR) is a space that supports cabling to areas outside the computer room. The TR is normally located outside the computer room but, if necessary, it can be combined with a MDA, IDA, or HDA.

The data center may support more than one telecommunications room if the areas to be served cannot be supported from a single telecommunications room.

The telecommunication rooms shall meet the specifications of ANSI/TIA-569-C.

6.12 Data center support areas

If the data center serves a critical function for an enterprise, consider terminating telecommunications cabling for the data center support areas and office space from telecommunications rooms outside the computer room.

The data center support areas are spaces outside the computer room that are dedicated to supporting the data center facility. These may include but are not limited to: the operation center, support personnel offices, security rooms, electrical rooms, mechanical rooms, storage rooms, equipment staging rooms, and loading docks.

The administrative and support areas shall be cabled similarly to standard office areas, as per ANSI/TIA-568-C.1. The operation center consoles and security consoles will require larger numbers of cables than standard work area requirements. The quantity should be determined with the assistance of the operations and technical staff. The operation center may also require cabling for large wall-mounted or ceiling-mounted displays (e.g., monitors and televisions).

The electrical rooms, mechanical rooms, storage rooms, equipment staging rooms, and loading docks should have at least one wall phone each. The electrical and mechanical rooms should also have at least one data connection for access to the facility management system.

6.13 Cabinets and racks

6.13.1 General

Cabinets and racks shall meet the specifications of ANSI/TIA-569-C.

6.13.2 "Hot" and "cold" aisles

Where alignment of cabinets is used to separate hot air and cold air, cabinets and racks shall be arranged in an alternating pattern, with fronts of cabinets/racks facing each other in a row to create "hot" and "cold" aisles. More efficient methods of hot or cold air containment may not require the orientation of cabinet/racks in a hot aisle/cold aisle configuration.

"Cold" aisles are in front of racks and cabinets. If there is an access floor, power distribution cables should be installed here under the access floor on the slab.

"Hot" aisles are behind racks and cabinets. If there is an access floor, cable trays for telecommunications cabling should be located under the access floor in the "hot" aisles.

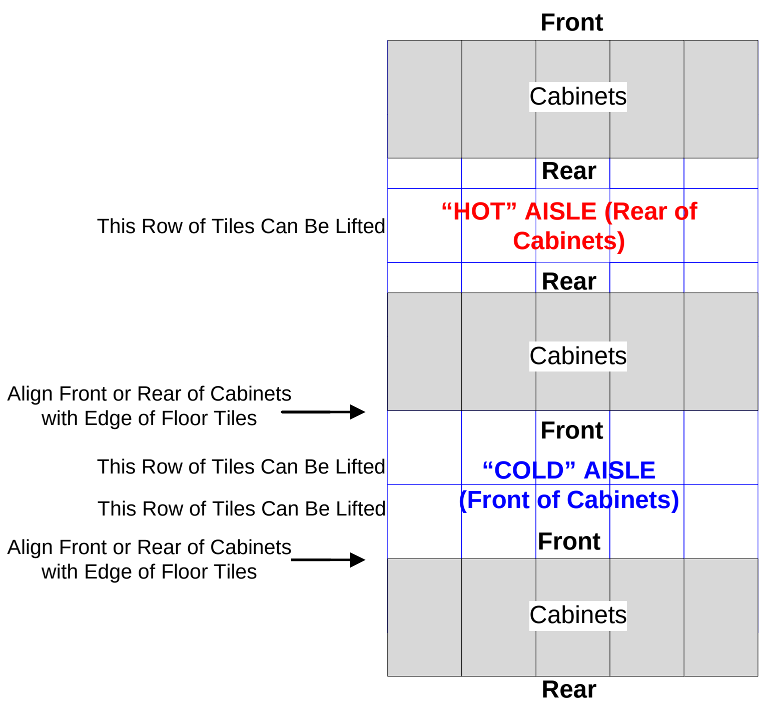


Figure 9: Example of "hot" aisles, "cold" aisles and cabinet placement

6.13.3 Placement relative to floor tile grid

When placed on access floor, cabinets and racks shall be arranged so that they permit tiles in the front and rear of the cabinets and racks to be lifted. Cabinets should be aligned with either the front or rear edge along the edge of the floor tile. Racks should be placed such that the threaded rods that secure the racks to the slab will not penetrate an access floor stringer.

6.13.4 Access floor tile cuts

Where under floor cooling is utilized, floor tiles cuts should only be used to:

- accommodate cabinet vents or cooling systems, or
- route cables from under floor to above floor.

In all cases, floor tile openings should be designed to seal, as tight as possible, against the penetrations to minimize loss of under floor air pressure. Brushes, flaps, or other methods to contain static air pressure should be employed.

Floor tile cuts for cabinets should be placed under the cabinets or other location where the floor tile cut will not create a tripping hazard.

Floor tile cuts for racks should be placed either: under the vertical cable managers between the racks, or under the rack (at the opening between the bottom angles). Generally, placing the floor tile cut under the vertical cable managers is preferable as it allows equipment to be located at the bottom of the rack.

6.13.5 Installation of racks on access floors

Seismic racks shall either be bolted to a seismic stand or bolted directly to the slab.

Racks that are supported by the access floor shall be bolted to the cement slab or a metal channel secured to the slab by threaded rods that penetrate through the floor tiles; or in accordance with guidance provided by the AHJ or a structural engineer.

Sharp edges on the top of the threaded rods shall be covered using domed nuts or other method. Exposed threads under the access floor should be covered using split tubing or other method.

6.13.6 Racks and cabinets in entrance room, MDAs, IDAs and HDAs

The entrance rooms, MDAs, IDAs, and HDAs should use 480 mm (19 in) racks for patch panels and equipment. Service providers may install their own equipment in the entrance room in either 585 mm (23 in) racks or proprietary cabinets.

In the entrance rooms, MDAs, IDAs, and HDAs, a vertical cable manager shall be installed between each pair of racks and at both ends of every row of racks. Vertical cable management shall be sized by calculating the maximum projected cable fill, including a minimum 50% additional growth factor (see ANSI/TIA-569-C). Where projected cable fill information is not available, consider deploying 250 mm (10 in) wide vertical cable managers. The cable managers should extend from the floor to the top of the racks.

In the entrance rooms, MDAs, IDAs and HDAs, horizontal cable management panels should be installed above and below each patch panel. The preferred ratio of horizontal cable management to patch panels is 1:1.

The vertical cable management, horizontal cable management, and slack storage should be adequate to ensure that the cables can be neatly dressed and that bend radius requirements specified in ANSI/TIA-568-C.0 are met.

7 DATA CENTER CABLING SYSTEMS

7.1 General

Data center cabling supports a multi-product, multi-vendor environment.

7.2 Choosing media

Cabling specified by this document is applicable to different application requirements within the data center environment. Depending upon the characteristics of the individual application, choices with respect to transmission media should be made. In making this choice, factors to be considered include:

- flexibility with respect to supported services;
- required useful life of cabling;
- facility/site size and occupant population;
- channel capacity within the cabling system; and
- equipment vendor recommendations or specifications.

7.3 Horizontal Cabling

7.3.1 General

The horizontal cabling extends from the equipment outlet to the horizontal cross-connect.

The following partial listing of common services and systems should be considered when the horizontal cabling is designed:

- voice, modem, and facsimile telecommunications service;
- premises switching equipment;
- computer and telecommunications management connections;
- keyboard/video/mouse (KVM) connections;
- data communications;
- wide area networks (WAN);
- local area networks (LAN);
- storage area networks (SAN); and
- other building signaling systems (building automation systems such as fire, security, power, HVAC, EMS, etc.).

In addition to satisfying today’s telecommunication requirements, the horizontal cabling should be planned to reduce ongoing maintenance and relocation. It should also accommodate future equipment and service changes. Consideration should be given to accommodating a diversity of user applications in order to reduce or eliminate the probability of requiring changes to the horizontal cabling as equipment needs evolve. The horizontal cabling can be accessed for reconfiguration under the access floor or overhead on cable tray systems. However, in a properly planned facility, disturbance of the horizontal cabling should only occur during the addition of new cabling.

7.3.2 Topology

The horizontal cabling shall meet the star topology requirements of ANSI/TIA-568-C.0. Each equipment outlet in the equipment distribution area (EDA) shall be connected via horizontal cable to a horizontal cross-connect in the horizontal distribution area (HDA), intermediate distribution area (IDA), or main distribution area (MDA) as shown in Figure 10.

Horizontal cabling shall contain no more than one consolidation point in the zone distribution area (ZDA) between the horizontal cross-connect and the equipment outlet. Refer to clause 6.9 for additional information regarding ZDAs.

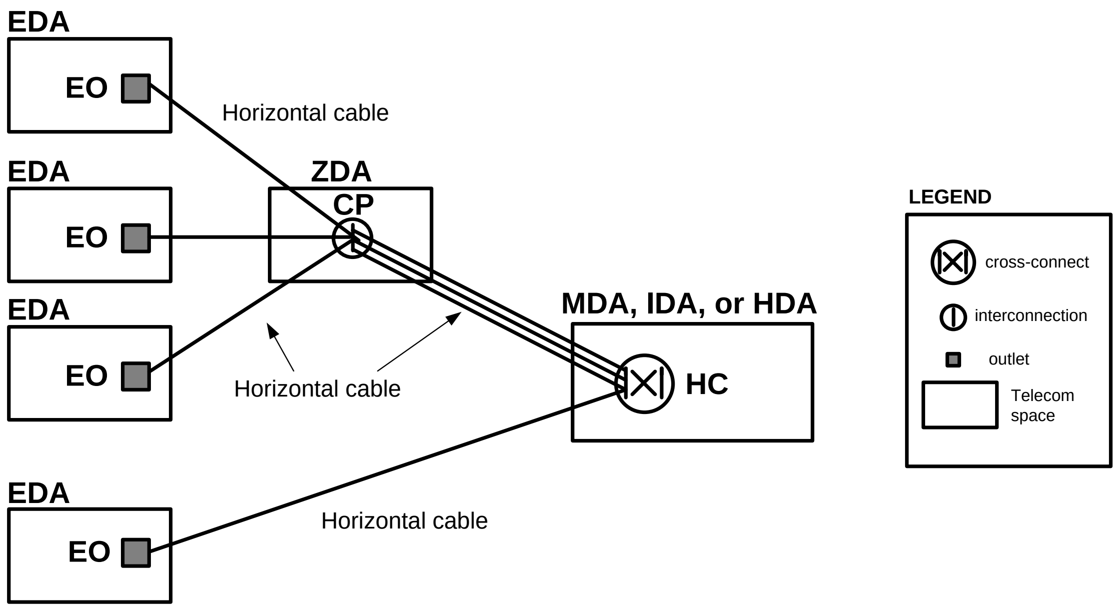


Figure 10: Typical horizontal cabling using a star topology

7.3.3 Horizontal cabling length

The horizontal cabling length shall meet the requirements of ANSI/TIA-568-C.0.

The maximum length of horizontal coaxial cabling from the MDA shall be as specified in Annex A of this Standard for the type of applications intended to run over the coaxial cabling.

7.3.4 Recognized media

Due to the wide range of services and site sizes where horizontal cabling will be used, more than one transmission medium is recognized. This Standard specifies transmission media, which shall be used individually or in combination in the horizontal cabling.

Recognized cables, related connecting hardware, jumpers, patch cords, equipment cords, and zone area cords shall meet the requirements specified in ANSI/TIA-568-C.2 and ANSI/TIA-568-C.3.

The recognized media are:

- 4-pair 100-ohm balanced twisted-pair cable (ANSI/TIA-568-C.2) – category 6 or category 6A, with category 6A recommended;
- 850 nm Laser-Optimized 50/125 um multimode fiber cable OM3 or OM4 (ANSI/TIA-568-C.3), with OM4 recommended;
- single-mode optical fiber cable (ANSI/TIA-568-C.3); and
- 75-ohm (734 and 735 type) coaxial cable (Telcordia Technologies GR-139-CORE) – used for T-1, T-3, E-1, and E-3 circuits only.

Channels constructed from recognized cables, associated connecting hardware, jumpers, patch cords, equipment cords, and zone area cords shall meet the requirements specified in ANSI/TIA-568-C.0, ANSI/TIA-568-C.2, ANSI/TIA-568-C.3 and ANSI/ATIS-0600404.2002 (DS3).

7.3.5 Optical fiber connectors

In new installations, where one or two fibers are used to make a connection, the LC connector (ANSI/TIA/EIA-604-10) shall be used. Where more than two fibers are used to make a connection, the MPO connector (ANSI/TIA-604-5-D) shall be used. The connector performance shall comply with ANSI/TIA-568-C.3.

7.3.6 Coaxial cable connectors

Coaxial connectors for 75-ohm (734 and 735 type) coaxial cables shall meet the requirements of ANSI/ATIS-0600404.2002 and shall additionally meet the following specifications:

- a characteristic Impedance of 75-ohm;
- a maximum insertion loss at 1 MHz to 22.5 MHz of 0.02 dB; and
- a minimum return loss at 1 MHz to 22.5 MHz of 35 dB.

Annex A permits the use of either TNC or BNC connectors, BNC connectors are recommended.

7.4 Backbone cabling

7.4.1 General

The function of the backbone cabling is to provide connections between the MDAs, IDAs, HDAs, telecommunications rooms, and entrance facilities in the data center cabling system. Backbone cabling consists of the backbone cables, main cross-connects, intermediate cross-connects, horizontal cross-connects, mechanical terminations, and patch cord or jumpers used for backbone-to-backbone cross-connection.

The backbone cabling is expected to serve the needs of the data center occupants for one or several planning phases, each phase spanning a time scale that may be on the order of months or years. During each planning period, the backbone cabling design should accommodate growth and changes in service requirements without the installation of additional cabling. The length of the planning period is ultimately dependent on the design logistics including material procurement, transportation, installation, and specification control.

The backbone cabling shall allow network reconfiguration and future growth without disturbance of the backbone cabling. The backbone cabling should support different connectivity requirements, including both the network and physical console connectivity such as: local area networks, wide area networks, storage area networks, computer channels, and equipment console connections.

7.4.2 Topology

7.4.2.1 Star topology

The backbone cabling shall meet the hierarchal star topology requirements of ANSI/TIA-568-C.0. There shall be no more than two hierarchical levels of cross-connects in the backbone cabling. From the horizontal cross-connect (HC), no more than one cross-connect shall be passed through to reach the MC. Therefore, connections between any two HCs shall pass through three or fewer cross-connect facilities.

Figure 11 shows an example of a typical data center backbone cabling using a star topology wherein each horizontal cross-connect in the HDA is cabled directly to a main cross-connect in the MDA.

> NOTE: The topology required by this Standard has been selected because of its acceptance and flexibility in meeting a variety of application requirements. The limitation to two levels of cross-connects is imposed to limit signal degradation for passive systems and to simplify moves, adds and changes.

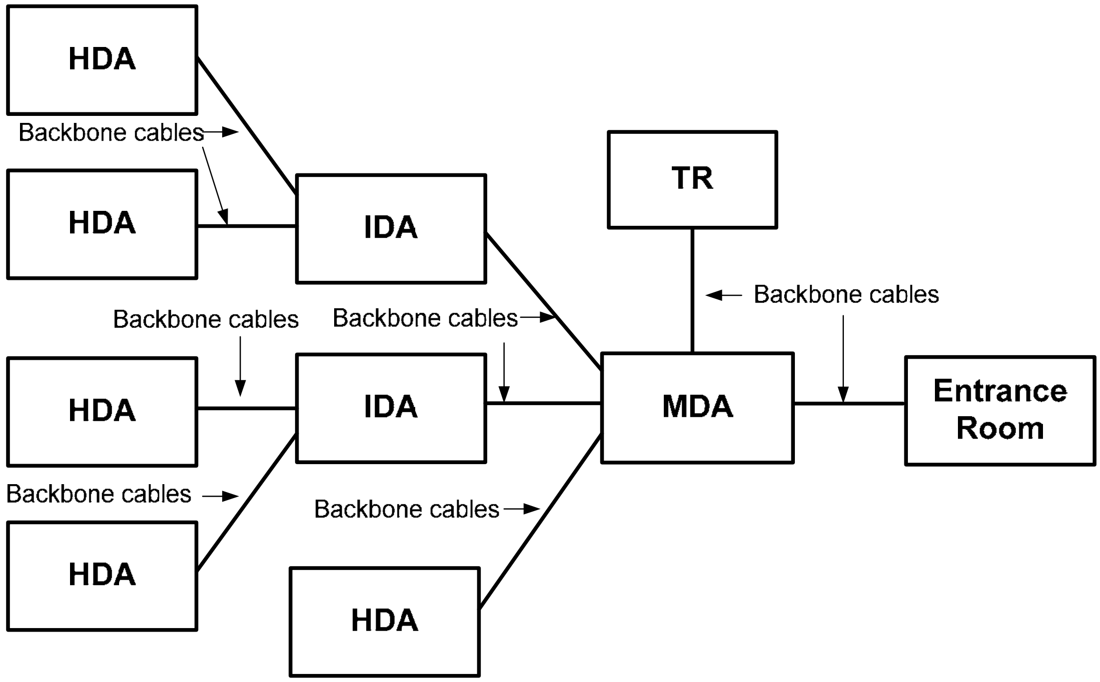


Figure 11: Typical backbone cabling using a star topology

If the horizontal cabling passes through the HDA, sufficient cable slack shall exist in the HDA to allow movement of the cables when migrating to a cross-connect.

Backbone cabling cross-connects may be located in telecommunications rooms, equipment rooms, MDAs, IDAs, HDAs or at entrance rooms.

7.4.2.2 Accommodation of non-star configurations

The topology in Figure 11, through the use of appropriate interconnections, electronics, or adapters in data center distribution areas, can often accommodate systems that are designed for non-star configurations such as ring, bus, or tree.

Cabling between HDAs should be permitted to provide redundancy and to avoid exceeding legacy application length restrictions.

7.4.3 Redundant cabling topologies

Redundant topologies can include a parallel hierarchy with redundant distribution areas. These topologies are in addition to the star topology specified in clauses 7.3.2 and 7.4.2. See clause 9 for additional information.

7.4.4 Recognized media

Due to the wide range of services and site sizes where backbone cabling will be used, more than one transmission medium is recognized. This Standard specifies transmission media, which shall be used individually or in combination in the backbone cabling.

The recognized media are:

- 100-ohm balanced twisted-pair cable (ANSI/TIA-568-C.2) with category 6A recommended;
- 850 nm Laser-Optimized 50/125 um multimode fiber cable OM3 or OM4 (ANSI/TIA-568-C.3), with OM4 recommended;
- single-mode optical fiber cable (ANSI/TIA-568-C.3); and
- 75-ohm (734 and 735 type) coaxial cable (Telcordia Technologies GR-139-CORE) – used for T-1, T-3, E-1, and E-3 circuits only.

Channels constructed from recognized cables, associated connecting hardware, jumpers, patch cords, equipment cords, and zone area cords shall meet the requirements specified in ANSI/TIA-568-C.0, ANSI/TIA-568-C.2, ANSI/TIA-568-C.3 and ANSI/ATIS-0600404.2002 (DS3).

7.4.5 Optical fiber connectors

In new installations, where one or two fibers are used to make a connection, the LC connector (ANSI/TIA/EIA-604-10) shall be used. Where more than two fibers are used to make a connection, the MPO connector (ANSI/TIA-604-5-D) shall be used. The connector performance shall comply with ANSI/TIA-568-C.3.

7.4.6 Coaxial cable connectors

Backbone coaxial cabling connectors shall meet the horizontal coaxial cabling connector specifications in 7.3.6.

7.4.7 Backbone cabling lengths

Cabling lengths are dependent upon the application and upon the specific media chosen (see ANSI/TIA-568-C.0 and the specific application standard). Annex A of this document provides guidelines for backbone lengths for data center applications.

7.5 Centralized optical fiber cabling

7.5.1 General

Centralized optical fiber cabling shall meet the requirements of ANSI/TIA-568-C.0. In a data center, centralized optical fiber cabling is designed as an alternative to the optical cross-connection located in the HDA when deploying recognized optical fiber cable in the horizontal in support of centralized electronics.

7.5.2 Implementation

The specifications of ANSI/TIA-568-C.0 shall be followed. In the cases of modular or containerized data center units, centralized optical fiber may extend beyond a single building.

To ensure correct fiber polarity, centralized cabling shall be implemented as specified in ANSI/TIA-568-C.0 and ANSI/TIA-568-C.0-2.

7.6 Cabling transmission performance and test requirements

7.6.1 General

Transmission performance depends on cable characteristics, connecting hardware, patch cords and cross-connect wiring, the total number of connections, and the care with which they are installed and maintained. See ANSI/TIA-568-C.0 for field test specifications for post-installation performance measurements of cabling designed in accordance with this Standard.

7.6.2 Additional requirements for field testing of 75-ohm coaxial cabling

Coaxial cabling shall be tested for:

- Center conductor continuity;
- Shield continuity;
- Impedance (75-ohms); and
- Insertion loss (less than the maximum specified in table 1 based on the planned applications for the cable).

Table 1: Maximum Coaxial Cable Insertion Loss

Application – Frequency	Maximum insertion loss from access provider DSX to customer equipment
CEPT-1 (E-1) - 1 MHz	3.6 dB
CEPT-3 (E-3) - 17.2 MHz	6.6 dB
T-3 - 22.4 MHz	6.9 dB

Coaxial cabling should be tested to ensure that end-to-end lengths are shorter than the lengths specified for the planned applications – see Annex A.

The cable tester should be calibrated for velocity of propagation using a sample length of the cable under test. As an alternative, length may be measured or determined using jacket length markings.

Note that the maximum lengths and maximum insertion loss values provided in this Standard are end-to-end from access provider DSX panel to customer equipment including coaxial cable patch cords.

Additionally, the cabling should be visually inspected for:

- Obvious damage to cable (for example, pinched cable, cuts or abrasion that exposes the shield);
- Incorrect bend radii; and
- Loose or damaged connectors.

8 DATA CENTER CABLING PATHWAYS

8.1 General

Except where otherwise specified, data center cabling pathways shall adhere to the specifications of ANSI/TIA-569-C.

Sizing of pathways should consider quantities of cables when the data center is fully occupied and all expansion areas are built. Particular attention is required for adequate capacity of pathways at entrance rooms, main distribution areas (MDAs), intermediate distribution areas (IDAs), horizontal distribution areas (HDAs), and intersections of cabling pathways.

8.2 Security for data center cabling

Telecommunications cabling for data centers shall not be routed through spaces accessible by the public or by other tenants of the building unless the cables are in enclosed conduit or other secure pathways. Any maintenance holes, pull boxes, or splice boxes shall be equipped with a lock.

Telecommunications entrance cabling for data centers should not be routed through a common equipment room (CER).

Any maintenance holes on building property or under control of the data center owner should be locked and monitored by the data center security system using a camera, remote alarm or both.

Access to pull boxes for data center cabling (entrance cabling or cabling between portions of the data center) that are located in public spaces or shared tenant spaces should be controlled. The pull boxes should also be monitored by the data center security system using a camera, remote alarm or both.

Any splice boxes for data center cabling that are located in public spaces or shared tenant spaces should be locked and monitored by the data center security system using a camera, remote alarm or both.

Entrance to utility tunnels used for telecommunications entrance rooms and other data center cabling should be locked. If the tunnels are used by multiple tenants or cannot be locked, telecommunications cabling for data centers shall be in solid metallic conduit or other secure pathway.

8.3 Separation of power and telecommunications cables

Separation is specified to accommodate the wide variety of equipment that may be present in a data center, but are not found in a typical office environment or telecommunications room.

8.3.1 Separation between power or lighting and balanced twisted-pair cables

The distances between power cables or lighting fixtures and balanced twisted-pair cables shall be maintained per ANSI/TIA-569-C.

8.3.2 Practices to accommodate power separation requirements

It is normally possible to meet the recommended separation distances through proper design and installation practices.

Branch circuits located under access floors in data centers should be in liquidtight flexible metal conduit (LFMC) or liquidtight flexible nonmetallic conduit (LFNC). Feeder circuits to power distribution units and panels should be installed in solid metal conduit. If the feeder circuits are not in solid metal conduit, they should be in liquidtight flexible metal conduit (LFMC) or liquidtight flexible nonmetallic conduit (LFNC).

In data centers that use overhead cable trays, the access headroom between the top of a tray or runway and the bottom of the tray or runway above shall be provided and maintained as specified in ANSI/TIA-569-C. This provides adequate separation if the electrical cables are shielded or if the power cable tray meets the specifications of the clause 8.3.1 and is above the telecommunications cable tray or runway.

In data centers that employ access floor systems, adequate separation of power and telecommunications cabling can be accommodated through the following measures:

- in the main aisles, allocate separate aisles for power and telecommunications cabling, if possible
- provide both horizontal and vertical separation of power and telecommunications cables where it is not possible to allocate separate aisles for power and telecommunications cabling in the main aisles. Provide horizontal separation by allocating different rows of tiles in the main aisles for power and telecommunications cabling, with the power and telecommunications cables as far apart from each other as possible. Additionally, provide vertical separation by placing the telecommunications cabling in cable trays or baskets as far above the power cables as possible.
- in the equipment cabinet aisles, allocate separate aisles for power and telecommunications cabling. Refer to ANSI/TIA-569-C for additional information on “hot” and “cold” aisles design

8.3.3 Separation of fiber and balanced twisted-pair cabling

Fiber and balanced twisted-pair cabling in cable trays and other jointly used pathways should be separated so that it improves administration and operation. Additionally, cords and jumpers should be separated from other cabling. Physical barriers between the two types of cables are not necessary.

Where it is not practical to separate fiber and balanced twisted-pair cables, fiber cables should be on top of balanced twisted-pair cables.

8.4 Telecommunications entrance pathways

8.4.1 Entrance pathway types

Telecommunications entrance pathways for data centers should be located underground. Aerial entrance pathways for telecommunications service entrance pathways are not recommended because of their vulnerability due to physical exposure.

8.4.2 Diversity

Refer to ANSI/TIA-758-B for information regarding entrance pathway diversity.

8.4.3 Sizing

The number of entrance conduits required depends on the number of access providers that will provide service to the data center, and the number and type of circuits that the access providers will provide. The entrance pathways should also have adequate capacity to handle growth and additional access providers.

Each access provider should have at least one metric designator 103 (trade size 4) conduit at each entrance point. Additional conduits may be required for campus cabling. Conduits used for optical fiber entrance cables should have three innerducts [two metric designator 40 (trade size 1.5) and one metric designator 27 (trade size 1) or three metric designator 32 (trade size 1.25)].

Consider the use of soft-sided duct material as a substitute for innerduct, which may optimize the use of finite conduit cross-sectional area.

8.5 Access floor systems

8.5.1 General

Access floor systems should be used in data centers that support equipment that is designed to be cabled from below.

Cables shall not be left abandoned under the access floor. Cables shall be terminated on at least one end in the MDA or a HDA, or shall be removed.

For additional information on rack and cabinet installation with access flooring systems, refer to ANSI/TIA-569-C.

8.5.2 Cable trays for telecommunications cabling

Telecommunications cabling under the access floor shall be in ventilated cable trays that do not block airflow. See ANSI/TIA-569-C for further cable tray design considerations. Under floor cable trays may be installed in multiple layers to provide additional capacity. Metallic cable tray shall be bonded to the data center grounding infrastructure. The cable tray should have a maximum depth of 150 mm (6 in).

To provide room for cables to exit the pathways, there shall be a minimum of 20 mm (0.75 in) from the bottom of the access floor tiles to the top of the cable tray and cabling in a cable pathway that is loaded 100% of calculated capacity.

The weight of fully loaded cable pathways shall be evaluated and coordinated with the access floor system designer.

Under floor systems that require periodic access or maintenance such as valves, electrical receptacles, and smoke detectors should not be located below under floor cable pathways unless there is an empty row of tiles adjacent to these pathways.

Under-floor cable tray routing should be coordinated with other under floor systems during the planning stages of the building. Refer to NEMA VE 2-2006 for recommendations regarding installation of cable trays.

Overhead cable trays should be routed to avoid impeding airflow, sprinkler patterns, and lighting. This typically implies routing cable trays over cabinets and racks rather than above aisles between them.

8.5.3 Access floor performance requirements

Access flooring shall meet the performance requirements of ANSI/TIA-569-C.

Access floors for data centers should use a bolted stringer understructure, as they are more stable over time than stringerless systems. Additionally, access floor stringers should be 1.2 m (4 ft) long installed in a “basketweave” pattern to improve stability. Pedestal adhesive should be applied under all base plates. Pedestal bases should also be bolted to the subfloor (with the exception of post-tension floors) for added stability in seismic areas.

8.5.4 Floor tile cut edging

Access floor tile cuts should have edging or grommets along all cut edges. If the edging or grommets are higher than the surface of the access floor, they shall be installed as not to interfere with placement of racks and cabinets. The edging or grommets shall not be placed where the racks and cabinets normally contact the surface of the access floor.

In the case of down-flow AC systems where the access flooring is being used as an air distribution plenum, floor tile cuts should be limited in both size and quantity to ensure proper airflow. In addition, floor tiles with cement or wood cores should have their exposed cut edges sealed in order to prevent core material from being blown into the computer room. After cuts are made to the access floor system and all equipment racks, cabinets, etc. are in place, it is recommended that the AC system be properly balanced.

8.5.5 Cable types under access floors

Cable fire-rating requirements vary by installation conditions and jurisdiction. Consult the AHJ before deciding on the type of cable to use under access floors.

NOTE – Consider the selection of cable types (e.g. plenum-rated) and fire suppression practices that minimize damage to equipment and the facility in the event of fire

8.6 Overhead cable trays

8.6.1 General

Overhead cable tray systems may alleviate the need for access floors in data centers that do not employ floor-standing systems that are cabled from below.

Overhead cable trays may be installed in several layers to provide additional capacity. Typical installations include two or three layers of cable trays, one for power cables and one or two for telecommunications cabling. One of the cable tray layers may employ brackets on one side that hold the data center grounding infrastructure. These overhead cable trays may be supplemented by a duct or tray system for fiber patch cables. The fiber duct or tray may be secured to the same hanging rods used to support the cable trays.

During the design phase, the weight of fully occupied cable pathways should be calculated and coordinated with a structural engineer.

Cable pathways should not be located where they interfere with proper operation of fire suppression systems such water distribution from sprinkler heads. Overhead cable pathways should not block airflow into or out of cabinets (e.g., not block air exiting the hot aisle or cabinet vents if located at the top of cabinets).

Cables shall not be left abandoned in overhead cable trays. Cables shall be terminated on at least one end in an MDA, IDA, or HDA, or shall be removed.

In aisles and other common spaces in internet data centers, co-location facilities, and other shared tenant data centers, overhead cable trays should have solid bottoms or be placed at least 2.7 m (9 ft) above the finished floor to limit accessibility or be protected through alternate means from accidental and/or intentional damage.

The maximum recommended depth of cable in any cable tray is 150 mm (6 in).

Typical cable tray types for overhead cable installation include telco-type cable ladders, center spine cable tray, or wire basket cable tray. The cable tray system shall be bonded and grounded per ANSI/TIA-607-B.

8.6.2 Cable tray support

Overhead cable trays should be suspended from the ceiling. Where building structural characteristics make overhead suspension of a cable tray impossible, the tray can be suspended from a structural grid that is supported by other means. If all racks and cabinets are of uniform height, the cable trays may be attached to the top of racks and cabinets, but this is not a recommended practice because suspended cable trays provide more flexibility for supporting cabinets and racks of various heights, and provide more flexibility for adding and removing cabinets and racks.

8.6.3 Coordination of cable tray routes

Planning of overhead cable trays for telecommunications cabling should be coordinated with architects, mechanical engineers, and electrical engineers that are designing lighting, plumbing, air ducts, power, and fire protection systems. Lighting fixtures and sprinkler heads should be placed between cable trays, not directly above cable trays. Cable trays should be located above cabinets and racks instead of above the aisles, where lighting should be located.

9 DATA CENTER REDUNDANCY

9.1 Introduction

Data centers that are equipped with diverse telecommunications facilities may be able to continue their function under unplanned or adverse conditions that would otherwise interrupt the data center's telecommunications service. This Standard includes four tiers relating to various levels of planned availability of the data center facility infrastructure. Information on infrastructure tiers can be found in annex F. Figure 12 illustrates various redundant telecommunications infrastructure components that can be added to the basic infrastructure.

The reliability of the telecommunications infrastructure can be increased by providing redundant cross-connect areas and pathways that are physically separated. It is common for data centers to have multiple access providers providing services, redundant routers, redundant core distribution and edge switches. Although this network topology provides a certain level of redundancy, the duplication in services and hardware alone does not ensure that single points of failure have been eliminated.

The proximity and response time of technicians required to perform repairs may affect reliability depending on the redundancy and architecture of the network and information technology infrastructure.

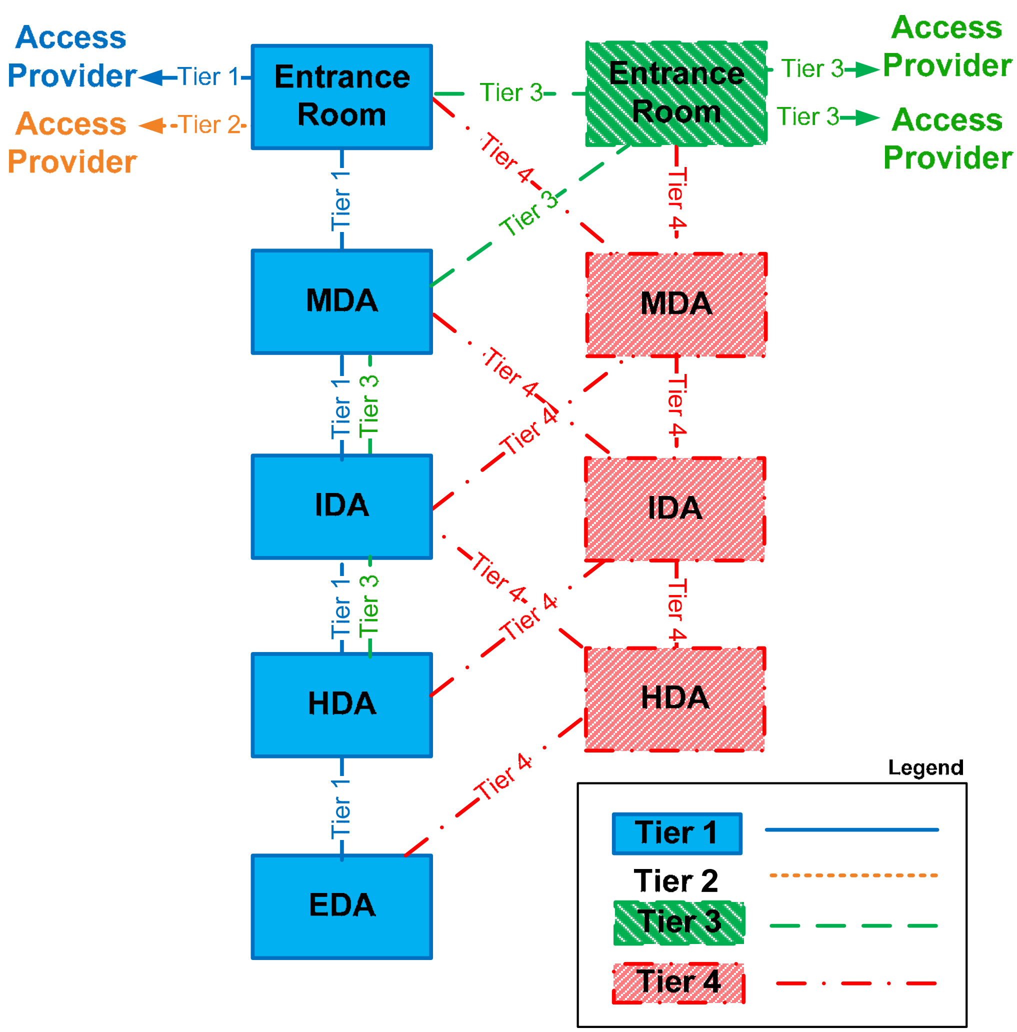


Figure 12: Telecommunications cabling pathway and space redundancy at various tiers

9.2 Redundant maintenance holes and entrance pathways

Multiple entrance pathways from the property line to the entrance room(s) eliminate a single point of failure for access provider services entering the building. These pathways will include customer-owned maintenance holes where the access provider conduits do not terminate at the building wall. The maintenance holes and entrance pathways should be on opposite sides of the building and be at least 20 m (66 ft) apart.

In data centers with two entrance rooms and two maintenance holes, it is not necessary to install conduits from each entrance room to each of the two maintenance holes. In such a configuration, each access provider is typically requested to install two entrance cables, one to the primary entrance room through the primary maintenance hole, and one to the secondary entrance room through the secondary maintenance hole. Conduits from the primary maintenance hole to the secondary entrance room and from the secondary maintenance hole to the primary maintenance hole provide flexibility, but are not required.

In data centers with two entrance rooms, conduits may be installed between the two entrance rooms to provide a direct path for access provider cabling between these two rooms (for example, to complete a SONET or SDH ring).

9.3 Redundant access provider services

Continuity of telecommunications access provider services to the data center can be ensured by using multiple access providers, multiple access provider central offices, and multiple diverse pathways from the access provider central offices to the data center.

Utilizing multiple access providers may increase service reliability in the event of an access provider-wide outage or access provider financial failure that impacts service.

Utilizing multiple access providers alone does not ensure continuity of service, because access providers often share space in central offices and share rights-of-way.

The customer should ensure that its services are provisioned from different access provider central offices and the pathways to these central offices are diversely routed. These diversely routed pathways should be physically separated by at least 20 m (66 ft) at all points along their routes.

9.4 Redundant entrance room

Multiple entrance rooms may be installed for redundancy rather than simply to alleviate maximum circuit length restrictions. Multiple entrance rooms improve redundancy, but complicate administration.

Access providers should install circuit provisioning equipment in both entrance rooms so that circuits of all required types can be provisioned from either room. Care should be taken to distribute circuits between entrance rooms. The access provider provisioning equipment in one entrance room should not be subsidiary to the equipment in the other entrance room. The access provider equipment in each entrance room should be able to operate in the event of a failure in the other entrance room.

The two entrance rooms should be at least 20 m (66 ft) apart and be in separated fire protection zones. The two entrance rooms should not share power distribution units or air conditioning equipment.

9.5 Redundant main distribution area

A secondary main distribution area (MDA) provides additional redundancy, but at the cost of complicating administration. Core routers and switches should be distributed between the two MDAs. Circuits should also be distributed between the two spaces.

The two MDAs should be in different fire protection zones, be served by different power distribution units, and be served by different air conditioning equipment.

9.6 Redundant backbone cabling

Redundant backbone cabling protects against an outage caused by damage to backbone cabling. Redundant backbone cabling may be provided in several ways depending on the degree of protection desired.

Backbone cabling between two spaces, for example, a HDA and a MDA, can be provided by running two cables between these spaces, preferably along different routes. If the data center has redundant MDAs or redundant IDAs, redundant backbone cabling to the HDA from each higher level distributor (IDA or MDA) is not necessary. However, the routing of cables from the HDA to the redundant IDAs or MDAs should follow different routes.

9.7 Redundant horizontal cabling

Horizontal cabling to critical systems can be diversely routed to improved redundancy. Care should be taken not to exceed maximum horizontal cable lengths when selecting paths.

Critical systems can be supported by two different HDAs as long as maximum cable length restrictions are not exceeded. The two HDAs should be in different fire protection zones for this degree of redundancy to provide maximum benefit.

ANNEX A (INFORMATIVE) CABLING DESIGN CONSIDERATIONS

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

A.1 Application cabling lengths

The maximum supportable lengths in this annex are application and media dependent.

See table 6 in ANSI/TIA-568-C.0 for balanced twisted pair applications and table 7 in ANSI/TIA-568-C.0 for optical fiber applications.

A.1.1 T-1, E-1, T-3 and E-3 circuit lengths

Table 2 provides the maximum circuit lengths for T-1, T-3, E-1, and E-3 circuits with no adjustments for intermediate connections or outlets between the circuit demarcation point and the end equipment. These calculations assume that there is no customer DSX panel between the access provider demarcation point (which may be a DSX) and the end equipment. The access provider DSX panel is not counted in determining maximum circuit lengths.

Table 2: Maximum circuit lengths with no DSX panel

Circuit type	Category 3	Category 5e, 6 & 6A	734 Type Coaxial	735 Type Coaxial
T-1	159 m (520 ft)	193 m (632 ft)	-	-
CEPT-1 (E-1)	116 m (380 ft)	146 m (477 ft)	332 m (1088 ft)	148 m (487 ft)
T-3	-	-	146 m (480 ft)	75 m (246 ft)
CEPT-3 (E-3)	-	-	160 m (524 ft)	82 m (268 ft)

NOTE: The lengths shown in table 2 are for the specific applications used in data centers and may be different from the lengths supported for various applications in ANSI/TIA-568-C.0.

Repeaters can be used to extend circuits beyond the lengths specified above.

These circuit lengths should be adjusted for insertion loss losses caused by a DSX panel between the access provider demarcation point (which may be a DSX panel) and the end equipment. Table 3 provides the reduction caused by DSX panels in maximum circuit lengths for T-1, T-3, E-1, and E-3 circuits over the recognized media type.

Table 3: Reduction in circuit lengths for DSX panel

Circuit type	Category 3	Category 5e, 6 & 6A	734 Type Coaxial	735 Type Coaxial
T-1	11 m (37 ft)	14 m (45 ft)	-	-
CEPT-1 (E-1)	10 m (32 ft)	12 m (40 ft)	64 m (209 ft)	28 m (93 ft)
T-3	-	-	13 m (44 ft)	7 m (23 ft)
CEPT-3 (E-3)	-	-	15 m (50 ft)	8 m (26 ft)

Maximum circuit lengths should be adjusted for insertion loss losses caused by intermediate connections and outlets. Table 4 provides the reduction in maximum circuit lengths for T-1, T-3, E-1, and E-3 circuits over the recognized media type.

Table 4: Reduction in circuit lengths per connection or outlet

Circuit type	Category 3	Category 5e, 6, & 6A	734 Type Coaxial	735 Type Coaxial
T-1	4.0 m (13.0 ft)	1.9 m (6.4 ft)	-	-
CEPT-1 (E-1)	3.9 m (12.8 ft)	2.0 m (6.4 ft)	4.4 m (14.5 ft)	2.0 m (6.5 ft)
T-3	-	-	0.9 m (3.1 ft)	0.5 m (1.6 ft)
CEPT-3 (E-3)	-	-	1.1 m (3.5 ft)	0.5 m (1.8 ft)

In the typical data center, there are a total of 3 connections in the backbone cabling, 3 connections in the horizontal cabling and no DSX panels between the access provider demarcation point and the end equipment.

Backbone cabling:

- one connection in the entrance room;
- two connections in the main cross-connect;
- no intermediate cross-connect.

Horizontal cabling:

- two connections in the horizontal cross-connect;
- an outlet connection at the equipment distribution area.

This “typical” configuration corresponds to the typical data center with an entrance room, main distribution area (MDA), one or more horizontal distribution areas (HDAs), and no zone distribution areas. Maximum circuit lengths for a typical data center configuration with six connections are shown in table 5. These maximum circuit lengths include backbone cabling, horizontal cabling, and all patch cords or jumpers between the access provider demarcation point and the end equipment.

Table 5: Maximum circuit lengths for the typical data center configuration

Circuit type	Category 3	Category 5e, 6, & 6A	734 Type Coaxial	735 Type Coaxial
T-1	135 m (442 ft)	184 m (603 ft)	-	-
CEPT-1 (E-1)	92 m (303 ft)	134 m (439 ft)	305 m (1001 ft)	137 m (448 ft)
T-3	-	-	141 m (462 ft)	72 m (236 ft)
CEPT-3 (E-3)	-	-	153 m (503 ft)	78 m (257 ft)

With maximum horizontal cable lengths, maximum patch cord lengths, no customer DSX, no intermediate distribution area (IDA), and no consolidation point, the maximum backbone cable lengths for T-1, E-1, T-3, or E-3 circuits are shown in table 6. This “typical” configuration assumes that the entrance room, MDA, and HDAs are separate rather than combined, and that there is no IDA. The maximum backbone cabling length is the sum of the length of cabling from the entrance room to the MDA and from the MDA to the HDA.

Table 6: Maximum backbone length for the typical data center configuration

Circuit type	Category 3	Category 5e, 6, & 6A	734 Type Coaxial	735 Type Coaxial
T-1	<1 m (<3 ft)	46 m (150 ft)	-	-
CEPT-1 (E-1)	<1 m (<3 ft)	<1 m (<3 ft)	190 m (624 ft)	29 m (95 ft)
T-3	-	-	26 m (85 ft)	0 m (0 ft)
CEPT-3 (E-3)	-	-	38 m (126 ft)	0 m (0 ft)

These calculations assume the following maximum patch cord lengths in the “typical” data center:

- 10 m (32.8 ft) for balanced twisted-pair and fiber in the entrance room, MDA, and HDA;
- 5 m (16.4 ft) for 734-type coaxial cable in the entrance room, MDA, and HDA;
- 2.5 m (8.2 ft) for 735-type coaxial cable in the entrance room, MDA, and HDA.

Due to the very short lengths permitted by category 3 balanced twisted-pair cabling and 735 type coaxial cable for T-1, T-3, E-1, and E-3 circuits, category 3 balanced twisted-pair and 735-type coaxial cables are not recommended for supporting these types of circuits.

Backbone cabling lengths can be increased by:

- limiting the locations where T-1, E-1, T-3, and E-3 circuits are provisioned (for example only in the MDA or horizontal cabling originating from the MDA);
- provisioning circuits from multiplexers or other circuit provisioning equipment located in the MDA, IDA, or HDA;
- provisioning circuits using horizontal cabling from the MDA, reducing the number of connections from six to two, and reducing the number of patch cords.

A.1.2 Baluns E-3 and T-3 circuits

Baluns permit E-3 and T-3 circuits to use twisted-pair cabling instead of 75-ohm coaxial cabling.

Lengths for E-3 and T-3 circuits over twisted pair cabling depends on a number of factors, including the electrical characteristics of the baluns, which are beyond the scope of this standard.

However, lengths for E-3 and T-3 circuits over twisted-pair cabling using baluns will be considerably shorter than the lengths for these circuits over 734 type coaxial cabling.

Taking into account only the insertion loss of the cabling and two twisted pair connections, the maximum lengths for E-3 and T-3 circuits with baluns over twisted-pair cabling is:

Table 7: Maximum circuit lengths over baluns NOT including insertion loss of baluns

Circuit type	Category 5e Cable & Panels	Category 6 Cable & Panels	Category 6A Cable & Panels
T-3	60.0 m (196.8 ft)	67,8 m (222.5 ft)	69.3 m (227.4 ft)
CEPT-3 (E-3)	66.2 m (217.2 ft)	74.5 m (244.2 ft)	75.9 m (249.1 ft)

These calculations assume that the baluns are attached directly to the access provider DSX panel, that there is no customer DSX panel, and that there are two twisted-pair connections. The lengths above need to be reduced by the following lengths for each decibel of insertion loss for the pair of baluns:

Table 8: Reduction in maximum circuit length for each 1 dB insertion loss for a pair of baluns

Circuit type	Category 5e Cable & Panels	Category 6 Cable & Panels	Category 6A Cable & Panels
T-3	10.2 m (33.4 ft)	11.1 m (36.6 ft)	11.4 m (37.4 ft)
CEPT-3 (E-3)	11.7 m (38.3 ft)	12.8 m (41.9 ft)	13.0 m (42.7 ft)

If the circuit is to pass through more than two connections, the circuit lengths will need to be reduced as described in table 9.

Table 9: Reduction in maximum circuit length for each additional twisted pair connection (after the 1st two)

Circuit type	Category 5e Cable & Panel	Category 6 Cable & Panel	Category 6A Cable & Panel
T-3	1.9 m (6.3 ft)	1.1 m (3.5 ft)	1.1 m (3.5 ft)
CEPT-3 (E-3)	1.9 m (6.4 ft)	1.1 m (3.5 ft)	1.1 m (3.5 ft)

A.1.3 TIA-232 and TIA-561 console connections

The recommended maximum lengths for TIA-232-F and TIA-561/562 console connections up to 20 kb/s are:

- 23.2 m (76.2 ft) over category 3 balanced twisted-pair cable;
- 27.4 m (89.8 ft) over category 5e or higher balanced twisted-pair cable.

The recommended maximum lengths for TIA-232-F and TIA-561/562 console connections up to 64 kb/s are:

- 8.1 m (26.5 ft) over category 3 balanced twisted-pair cable;
- 9.5 m (31.2 ft) over category 5e or higher balanced twisted-pair cable.

A.2 Cross-connections

In the entrance room, MDA, IDA, and HDA, jumper and patch cord lengths used for cross-connection to backbone cabling should not exceed 20 m (66 ft).

The only exception to these length restrictions should be in the case of 75-ohm coaxial cables, for DS-3 patching, the maximum length should be 5 m (16.4 ft) for type 734 coaxial and 2.5 m (8.2 ft) for type 735 coaxial in the entrance room, main cross-connect, intermediate cross-connect, and horizontal cross-connects.

A.3 Separation of functions in the main distribution area

The MDA should have separate racks for balanced twisted-pair, coaxial cable, and optical fiber distribution unless the data center is small and the main cross-connect can fit in one or two racks. Separate patching bays for balanced twisted-pair cables, coaxial cables, and optical fiber cables simplify management and serves to minimize the size of each type of patching bay. Arrange patching bays and equipment in close proximity to minimize patch cord lengths.

A.3.1 Twisted-pair main cross-connect

The twisted-pair main cross-connect (MC) supports twisted-pair cable for a wide range of applications including low speed circuits, T-1, E-1, consoles, out-of-band management, KVM, and LANs.

Consider installing category 6A twisted-pair cabling for all balanced twisted-pair cabling from the MC to the intermediate cross-connects (ICs) and HCs, as this will provide maximum flexibility for supporting a wide variety of applications. Cabling from the E-1/T-1 demarcation area in the entrance room should be 4-pair category 5e or higher.

The type of terminations in the MC (IDC connecting hardware or patch panels) depends on the desired density and where the conversion from 1- and 2-pair access provider cabling to 4-pair computer room structured cabling occurs:

- if the conversion from 1- and 2-pair access provider cabling occurs in the entrance room, then balanced twisted-pair cable terminations in the MC are typically on patch panels. This is the recommended configuration;
- if the conversion from 1- and 2-pair access provider cabling occurs in the MC, then balanced twisted-pair cable terminations in the MC should be on IDC connecting hardware.

A.3.2 Coaxial main cross-connect

The coaxial MC supports coaxial cable for T-3 and E-3 cabling (two coaxial cables per circuit). For smaller data centers and shorter cable runs, 735-type coaxial cable may be considered. All other coaxial cabling should be 734-type coaxial cable.

Termination of coaxial cables should be on patch panels with 75-ohm BNC connectors. The BNC connectors should be female-BNC on both the front and back of the patch panels.

A.3.3 Optical fiber main cross-connect

The fiber MC supports optical fiber cable for local area networks, storage area networks, metropolitan area networks, computer channels, and SONET circuits.

Termination of fiber cables should be on fiber patch panels.

A.4 Separation of functions in the horizontal distribution area

HDAs should have separate cabinets or racks for balanced twisted-pair, coaxial cable, and optical fiber distribution unless the horizontal cross-connect is small and only requires one or two racks. Separate patching bays for balanced twisted-pair cables, coaxial cables, and optical fiber cables simplify management and minimize the size of each type of patching bay. Arrange patching bays and equipment in close proximity to minimize patch cord lengths.

The use of a single type of cable simplifies management and improves flexibility to support new applications. Consider installing only one type of balanced twisted-pair cable and only one type of optical fiber cable for horizontal cabling (for example all category 6 or all category 6A, and all OM4 cable or all OM3 cable).

A.5 Cabling to end equipment

Equipment cord lengths from the ZDA should be limited to a maximum of 22 m (72 ft) in the case of balanced twisted-pair or fiber optic cabling.

If individual equipment outlets are located on the same equipment rack or cabinet as the equipment served in lieu of a ZDA, equipment cord lengths should be limited to 5 m (16 ft).

A.6 Fiber design consideration

High termination density can be achieved using multi-fiber increments and the use of MPO connectors. If cable lengths can be accurately pre-calculated, pre-terminated multi-fiber cable assemblies can reduce installation time. In these cases, the effects of additional connections should be considered to ensure overall fiber system performance. High data-rate end equipment may accommodate multi-fiber connectors directly (e.g., 40/100G Ethernet with multimode fiber).

A.7 Balanced twisted-pair design consideration

The patch panels should provide adequate space for labeling of each patch panel with its identifier as well as labeling each port as per ANSI/TIA-606-B requirements.

ANNEX B (INFORMATIVE) ACCESS PROVIDER INFORMATION

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

B.1 Access provider coordination

B.1.1 General

Data center designers should coordinate with local access providers to determine the access providers' requirements and to ensure that the data center requirements are provided to the access providers.

B.1.2 Information to provide to access providers

Access providers will typically require the following information for planning entrance rooms for a data center:

- address of the building;
- general information concerning other uses of the building, including other tenants;
- plans of telecommunications entrance conduits from the property line to the entrance room, including location of maintenance holes, hand holes, and pull boxes;
- assignment of conduits and innerducts (or soft-sided subducts) to the access provider;
- floor plans for the entrance facilities;
- assigned location of the access providers protectors, racks, and cabinets;
- routing of cables within entrance room (under access floor, overhead cable ladders, other);
- expected quantity and type of circuits to be provisioned by the access provider;
- date that the access provider will be able to install entrance cables and equipment in the entrance room;
- requested location and interface for demarcation of each type of circuit to be provided by the access provider;
- requested service date; and
- name, telephone number, and email address of primary customer contact and local site contact.

B.1.3 Information that the access providers should provide

The access provider should provide the following information:

- conduit requirements, including:
    - size and quantity
    - innerduct (or soft-sided subduct) size and quantity (if owner installed)
    - bend limitations
    - pull string placement
    - minimum burial depth
    - locate wire or locate ball placement
    - stub up location and specifications
- grounding requirements;
- backboard sizing;
- final grading and landscape impact;
- handhole or maintenance hole location;

- space and mounting requirements for protectors on balanced twisted-pair cables;
- quantity and dimensions of access provider racks and cabinets;
- power requirements for equipment, including receptacle types;
- service clearances; and
- installation and service schedule.

B.2 Access provider demarcation in the entrance room

B.2.1 Organization

The entrance room will have up to four separate areas for access provider demarcation:

- demarcation for low-speed balanced twisted-pair circuits, including DS-0, ISDN BRI, and telephone lines;
- demarcation for high-speed DS-1 (T-1 or fractional T-1, ISDN PRI) or CEPT-1 (E-1) balanced twisted-pair circuits;
- demarcation for circuits delivered on coaxial cable including DS-3 (T-3) and CEPT-3 (E-3); and
- demarcation for optical fiber circuits (for example, SONET OC-x, SDH STM-x, Fast Ethernet, Gigabit Ethernet, 10 Gigabit Ethernet, 40 Gigabit Ethernet, and 100 Gigabit Ethernet).

Ideally, all access providers provide demarcation for their circuits in the same location rather than in their own racks. This simplifies cross-connects and management of circuits. The centralized location for demarcation to all access providers is often called meet-me areas or meet-me racks. There should be separate meet-me or demarcation areas or racks for each type of circuit; low speed, E-1/T-1, E-3/T-3, and optical fiber. Cabling from the computer room to the entrance room should terminate in the demarcation areas.

If an access provider prefers to demarcate their services in their racks, the customer can install tie-cables from that access provider’s demarcation point to the desired meet-me/demarcation area.

B.2.2 Demarcation of low-speed circuits

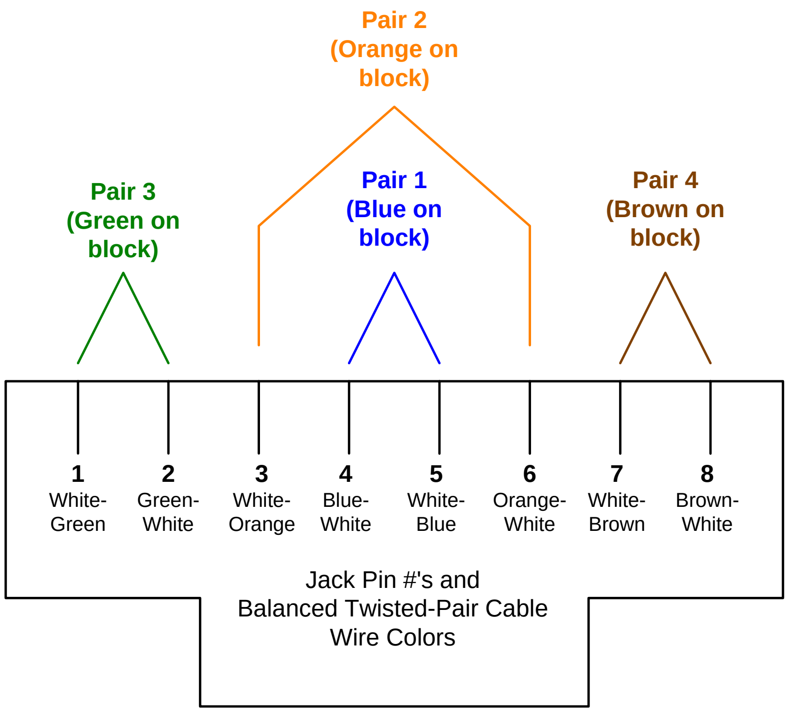
Access providers should be asked to provide demarcation of low-speed circuits on IDC connecting hardware. While service providers may prefer a specific type of IDC connecting hardware (e.g. 66 block), they may be willing to hand off circuits on another type of IDC connecting hardware upon request.

Cabling from the low-speed circuit demarcation area to the MDA should be terminated on IDC connecting hardware near the access provider IDC connecting hardware.

Circuits from access providers are terminated either in one or two pairs on the access provider IDC connecting hardware. Different circuits have different termination sequences, as illustrated in Figure 13 and Figure 14.

Each 4-pair cable should be terminated in an eight-position modular jack at the EDA. The 100 ohm balanced twisted-pair equipment outlet/connector should meet the modular interface requirements specified in IEC 60603-7. In addition, the telecommunications outlet/connector for 100 ohm balanced twisted-pair cable should meet the requirements of ANSI/TIA-568-C.2 and the terminal marking and mounting requirements specified in ANSI/TIA-570-B.

Pin/pair assignments should be as shown in Figure 13 or, optionally, per Figure 14 if necessary to accommodate certain 8-pin cabling systems. The colors shown are associated with the horizontal distribution cable. These illustrations depict the front view of the equipment outlet and provide the list of the pair position for various circuit types.



(View from Front of Jack or Back of Plug)

1) **Phone Lines**:1-pair cross-connect to Pair 1**(Blue**)

2) **ISDN BRI U-Interface (U.S.)**: 1-pair cross-connect to Pair 1 (**Blue)**

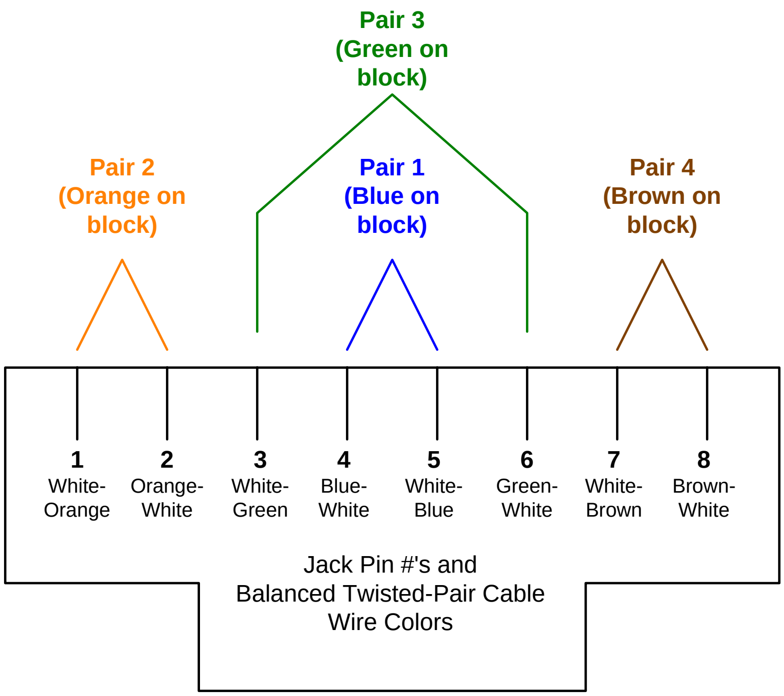
3) **ISDN BRI S/T-Intf (Intl)**: 2-pair cross-connect to Pairs 1 & 2 (**Blue** & **Orange**)

4) **56k/64k Leased Line**: 2-pair cross-connect to Pairs 3 & 4 (**Green** & **Brown**)

5) **E1/T1**: 2-pair cross-connect to Pairs 1 & 3 (**Blue** & **Green**)

6) **10Base-T/100Base-T**: 2-pair cross-connect to Pairs 2 & 3 (**Orange** & **Green**)

Figure 13: Cross-connection circuits to IDC connecting hardware cabled to modular jacks in the T568A 8-pin sequence



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5) **E1/T1**: 2-pair cross-connect to Pairs 1 & 2 (**Blue** & **Orange**)

6) **10Base-T/100Base-T**: 2-pair cross-connect to Pairs 2 & 3 (**Orange** & **Green**)

Figure 14: Cross-connection circuits to IDC connecting hardware cabled to modular jacks in the T568B 8-pin sequence

The conversion from access provider 1-pair and 2-pair cabling to 4-pair cabling used by the data center structured cabling system can occur either in the low-speed circuit demarcation area or in the main distribution area (MDA).

The access provider and customer IDC connecting hardware can be mounted on a plywood backboard, frame, rack, or cabinet. Dual-sided frames should be used for mounting large numbers of IDC connecting hardware (3000+ pairs).

B.2.3 Demarcation of T-1 circuits

Access providers should be asked to hand-off T-1 circuits on RJ48X jacks (individual 8-position modular jacks with loop back), preferably on a DSX-1 patch panel mounted on a customer-owned rack installed in the DS-1 demarcation area. Patch panels from multiple access providers and the customer may occupy the same rack.

For example, in the United States and Canada, access providers typically use DSX-1 patch panels that fit 585 mm (23 in) racks. Thus, the DS-1 demarcation area should use one or more 585 mm (23 in) racks for access provider DS-1 patch panels. These same racks or adjacent 480 mm (19 in) racks can accommodate patch panels for cabling to the MDA. Outside the United States and Canada, access providers typically use DSX-1 panels that fit in 480 mm (19 in) racks.

The DSX-1 patch panels may require power for indicator lights. Thus, racks supporting access provider DSX-1 patch panels should, at minimum have one 20A 120V circuit and a multi-outlet power strip.

Allocate rack space for access provider and customer patch panels including growth. Access providers may require rack space for rectifiers to power DSX-1 patch panels.

Access providers can alternatively hand off DS-1 circuits on IDC connecting hardware. These IDC connecting hardware can be placed on the same frame, backboard, rack, or cabinet as the IDC connecting hardware for low-speed circuits.

A single 4-pair cable can accommodate one T1 transmit and receive pair. When multiple T1 signals are placed over multi-pair unshielded twisted-pair cable, the transmitted signals should be placed in one cable and the receive signals placed in a separate cable.

If the data center support staff has the test equipment and knowledge to troubleshoot T-1 circuits, the DS-1 demarcation area can use DSX-1 panels to terminate T-1 cabling to the MDA. These DSX-1 panels should have either modular jacks or IDC terminations at the rear.

The IDC connecting hardware, modular jack patch panels, or DSX-1 panels for cabling to the MDA can be on the same or separate racks, frames, or cabinets as the ones used for access provider DSX-1 patch panels. If they are separate, they should be adjacent to the racks assigned to the access providers.

The customer (data center owner) may decide to provide its own multiplexers (M13 or similar multiplexer) to demultiplex access provider T-3 circuits to individual T-1 circuits. T-1 circuits from a customer-provided multiplexer should not be terminated in the T-1 demarcation area.

B.2.4 Demarcation of E-3 & T-3 circuits

Access providers should be asked to hand-off E-3 or T-3 circuits on pairs of female BNC connectors, preferably on a DSX-3 patch panel on a customer-owned rack installed in the E-3/T-3 demarcation area. Patch panels from multiple access providers and the customer may occupy the same rack.

In the United States and Canada, access providers typically use DSX-3 patch panels that fit 585 mm (23 in) racks. Thus, the E-3/T-3 demarcation area should use one or more 585 mm (23 in) racks for access provider DSX-3 patch panels. These same racks or adjacent 480 mm (19 in) racks can accommodate patch panels for cabling to the MDA. Outside North America, access providers typically use DSX-3 panels that fit 480 mm (19 in) racks.

If the data center support staff has the test equipment and knowledge to troubleshoot E-3 or T-3 circuits, the E-3/T-3 demarcation area can use DSX-3 panels to terminate 734-type coaxial cabling to the MDA. These DSX-3 panels should have BNC connectors at the rear.

The DSX-3 patch panels may require power for indicator lights. Thus, racks supporting access provider DSX-3 patch panels should, at minimum have one 20A 120V circuit and a multi-outlet power strip.

Allocate rack space for access provider and customer patch panels including growth. Access providers may require rack space for rectifiers to power DSX-3 patch panels.

Cabling from the E-3/T-3 demarcation area to the MDA should be 734-type coaxial cable. Cables in the E-3/T-3 demarcation area can be terminated on a customer patch panel with 75-ohm BNC connectors, or directly on an access provider DSX-3 patch panel. Access provider DSX-3 patch panels typically have the BNC connectors on the rear of the panels. Thus, BNC patch panels for cabling to the MDA should be oriented with the front of the patch panels on the same side of the rack as the rear of the access provider DSX-3 panels.

All connectors and patch panels for E-3 and T-3 cabling should use 75-ohm BNC connectors.

B.2.5 Demarcation of optical fiber circuits

Access providers should be asked to hand-off optical fiber circuits on fiber patch panels installed on racks in the fiber demarcation area. Fiber patch panels from multiple access providers and the customer may occupy the same rack. If requested, access providers may be able to use the same connector to simplify patch cord requirements.

In the United States and Canada, access providers typically use fiber patch panels that fit 585 mm (23 in) racks, but may be able to provide patch panels that fit 480 mm (19 in) racks, if requested. In the United States, it is usually prudent to use 585 mm (23 in) racks for access provider fiber patch panels in the fiber demarcation area. These same racks or adjacent 480 mm (19 in) racks can accommodate patch panels for cabling to the MDA. Outside North America, access providers typically use fiber patch panels that fit 480 mm (19 in) racks.

The racks in the fiber demarcation area do not require power except possibly utility outlets for access provider and customer test equipment.

Cabling from the demarcation area to the MDA should be same fiber type as the access provider cabling.

ANNEX C (INFORMATIVE) COORDINATION OF EQUIPMENT PLANS WITH OTHER ENGINEERS

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

Coordinate placement of equipment and lighting in the data centers so that lighting fixtures are placed in aisles between cabinets and racks instead of directly over equipment rows.

Coordinate placement of equipment and sprinklers in the data centers so that tall cabinets or overhead cable trays do not block water dispersal from the sprinklers – the minimum clearance by Code is 460 mm (18 in). Electrical engineers will need to know placement and power requirements for equipment cabinets and racks. Coordinate routing of power cabling and receptacles with routing of telecommunications cabling and placement of equipment.

Mechanical engineers will need to know cooling requirements for equipment cabinets and racks. Coordinate placement of cable trays and telecommunications cabling to ensure that adequate airflow is maintained to all parts of the computer room. Airflow from cooling equipment should be parallel to rows of cabinets and racks. Perforated tiles should be placed in “cold” aisles, not “hot” aisles.

ANNEX D (INFORMATIVE) DATA CENTER SPACE CONSIDERATIONS

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

The data center should have an adequately sized storage room so that boxed equipment, spare air filters, spare floor tiles, spare cables, spare equipment, spare media, and spare paper can be stored outside the computer room. The data center should also have a staging area for unpacking and possibly for testing new equipment before deploying them in the computer room. It is possible to dramatically reduce the amount of airborne dust particles in the data center by having a policy of un-packaging all equipment in the build/storage room.

The required square footage of space is intimately related to the layout of the space, including not only equipment racks and/or cabinets, but also cable management and other supporting systems such as electrical power, HVAC and fire suppression. These supporting systems have space requirements that depend upon the required level of redundancy.

If the new data center replaces one or more existing data centers, one way to estimate the size of the data center is to inventory the equipment to be moved into the new data center and create a floor plan of the new data center with this equipment and expected future equipment with desired equipment adjacencies and desired clearances. The layout should assume that the cabinets and racks are efficiently filled with equipment. The floor plan should also take into account any planned technology changes that might affect the size of the equipment to be located in the new data center. The new computer room floor plan will need to include electrical and HVAC support equipment.

Often an operations center and a printer room are spaces with data center adjacency requirements, and are best designed together with the data center. The printer room should be separated from the main computer room and have a separate HVAC system because the printers generate paper and toner dust, which are detrimental to computer equipment. NFPA 75 specifies separate rooms for storage of spare media and forms. Additionally, it is a good practice to have a separate tape room for tape drives, automated tape libraries, and tape libraries because of the toxicity of smoke from burning tape.

Consider separate spaces or rooms outside the computer room for electrical, HVAC, and fire suppression system equipment, although space is not used as efficiently, security is improved because vendors and staff that service this equipment don’t need to enter the computer room.

ANNEX E (INFORMATIVE) DATA CENTER SITE SELECTION AND BUILDING DESIGN CONSIDERATIONS

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

E.1 General

Considerations that are important to a specific tier level are provided in the tiering chart in annex F. Additionally, the considerations in this annex apply to higher tier data centers.

The building should conform to all applicable national, state, and local codes.

The building and site should meet all current applicable local, state, and federal accessibility guidelines and standards.

The building should conform to the seismic standards applicable to the International Building Code Seismic Zone of the site.

The building should be free of asbestos, paint containing lead, polychlorinated biphenyl, and other environmental hazards.

Consideration should be given to zoning ordinances and environmental laws governing land use, fuel storage, sound generation, and hydrocarbon emissions that may restrict fuel storage and generator operation.

Consideration should be given to geographic location as it may impact power and cooling efficiency and availability. The difficulty in properly cooling equipment increases with altitude, thus data centers should be located below 3050 m (10,000 ft) elevation as recommended by ASHRAE.

E.2 Architectural site selection and building design considerations

The need for redundant access to the building from separate roads should be considered.

The building should be provided with sufficient parking to meet all applicable codes. Consideration should be given to “exit strategies”, which may require additional parking.

Sufficient space should be provided for all mechanical and electrical support equipment, including indoor, outdoor, and rooftop equipment. Consideration should be given to future equipment requirements.

The building should have a sufficiently large loading dock, freight elevator, and pathway to handle all anticipated deliveries of supplies and equipment.

The computer room should be located away from sources of EMI and RFI such as x-ray equipment, radio transmitters, and transformers.

The data center and all support equipment should be located above the highest expected floodwater levels. No critical electronic, mechanical or electrical equipment should be located in basement levels.

Avoid locating computer room below plumbed areas such as rest rooms, janitor closets, kitchens, laboratories, and mechanical rooms.

The computer room should have no exterior windows. If there are windows in a proposed computer room space, they should be covered for security reasons and to minimize any solar heat gain.

E.3 Electrical site selection and building design considerations

The local utility company should be able to provide adequate power to supply all initial and future power requirements for the data center. The availability and economics of redundant utility feeders possibly from separate utility substations should be considered where applicable. If the local utility cannot provide adequate power, the site should be able to support self-generation, cogeneration or distributed generation equipment. Underground utility feeders are preferable to overhead feeders to minimize exposure to lightning, trees, traffic accidents, and vandalism.

E.4 Mechanical site selection and building design considerations

A multi-tenant building will require a location designated by the landlord either on the roof or on grade for air conditioning heat rejection equipment (condensing units, cooling towers, or dry fluid coolers).

If the building has an existing fire suppression system it should be easily modified to a pre-action sprinkler system dedicated to the data center. If the building has an existing air conditioning system serving the data center space it should be a system and type applicable for data centers based on a minimum 10 m^2 (100 ft^2) per ton, including both the computer room space and support areas.

If heat rejection equipment is to be placed on-grade, then a data center site should have adequate on-grade space for the equipment and the area should be provided with unobstructed access for equipment installation and removal.

E.5 Telecommunications site selection and building design considerations

The building should be served by at least two diversely routed optical fiber entrance rooms. These entrance rooms should be fed from different local access provider offices. If the building is only served by a single local central office, then the service feed from the second local central office should be capable of being added without major construction or delays in obtaining permits.

Multiple telecommunications access providers should provide service or be able to provide service to the building without major construction or delays in obtaining permits.

The data center should be served by dedicated access provider equipment located in the data center space and not in shared tenant space. The access provider entrance cables should be enclosed in conduit within the building and be inaccessible to other tenants where routed through shared pathways. The building should have dedicated conduits serving the data center space for telecommunications service.

E.6 Security site selection and building design considerations

If cooling equipment, generators, fuel tanks, or access provider equipment is situated outside the customer space, then this equipment should be adequately secured.

Also, the data center owner will need access to this space 24 hrs/day, 7 days/week.

Common areas should be monitored by cameras, including parking lots, loading docks, and building entrances.

The computer room should not be located directly in close proximity to a parking garage.

The site should not be located in a 100-year flood plain, near an earthquake fault, on a hill subject to slide risk, or downstream from a dam or water tower. Additionally there should be no nearby sites that could create falling debris during an earthquake.

The site should not be in the flight path of any nearby airports.

The site should be no closer than 0.8 km (½ mile) from a railroad or major interstate highway to minimize risk of chemical spills.

The site should not be within 0.4 km (¼ mile) of an airport, research lab, chemical plant, landfill, river, coastline, or dam.

The site should not be within 0.8 km (½ mile) of a military base.

The site should not be within 1.6 km (1 mile) of nuclear, munitions, or defense plants.

The site should not be located adjacent to a foreign embassy.

The site should not be located in high crime areas.

E.7 Other site selection considerations

Other data center site selection criteria to consider are:

- risk of contamination;
- proximity of police stations, fire stations, and hospitals;
- general access;
- zoning ordinances;
- vibration;
- environmental issues; and
- alternate uses of the building or site after it is no longer needed as a data center (exit strategies).

ANNEX F (INFORMATIVE) DATA CENTER INFRASTRUCTURE TIERS

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

F.1 General

It should be noted that human factors and operating procedures may have a greater impact on availability than the tier rating of the data center. This tiering scheme suggests a limited set of steps intended to improve data center reliability. It is not intended to be all-inclusive. Additional or alternative schemes are available in other standards.

F.1.1 Redundancy overview

Single points of failure should be eliminated to improve redundancy and reliability, both within the data center and support infrastructure as well as in the external services and utility supplies.

This Standard includes four tiers relating to various level of resiliency of the data center facility infrastructure. The tier ratings correspond to the industry data center tier ratings as defined by The Uptime Institute, but the definitions of each tier have been expanded in this Standard.

F.1.2 Tiering overview

This Standard includes four tiers relating to various levels of resiliency of the data center facility infrastructure. Higher tiers not only correspond to higher resiliency, but also lead to higher construction costs. In all cases, higher rated tiers are inclusive of lower level tier requirements unless otherwise specified.

A data center may have different tier ratings for different portions of its infrastructure. For example, a data center may be rated tier 3 for electrical, but tier 2 for mechanical. For the sake of simplicity, a data center that is rated the same for all subsystems (telecommunications, architectural and structural, electrical and mechanical) can be called out by its tier overall (e.g. a tier 2 data center would have a tier 2 rating in all subsystems). However where not all portions of the infrastructure are at the same level, the tiering should be called out specifically. For example, a data center may be a tier rating of T_2 E_3 A_1 M_2 where:

- telecommunications is tier 2 (T_2);
- electrical is tier 3 (E_3);
- architectural infrastructure is tier 1 (A_1); and
- mechanical infrastructure is tier 2 (M_2).

Although typically a data center's overall rating is based on its weakest component, there may be mitigating circumstances relative to that facilities specific risk profile, operational requirements or other factors that justify the lower rating in one or more subsystems.

Different areas within a data center may also be built and or used at different tier levels dependant on operational needs. In such cases care should be given to describe these differences, for example an area of a data center that has a tier 2 risk avoidance profile because it has T_2, E_2, A_2 M_2 services within a facility that may be Tier 3.

Care should be taken to maintain mechanical and electrical system capacity to the correct tier level as the data center load increases over time. For example, a data center may be degraded from tier 3 or tier 4 to tier 1 or tier 2 as redundant capacity is utilized to support new computer and telecommunications equipment.

F.2 Redundancy

F.2.1 N - Base requirement

System meets base requirements and has no redundancy.

F.2.2 N+1 redundancy

N+1 redundancy provides one additional unit, module, path, or system in addition to the minimum required to satisfy the base requirement. The failure or maintenance of any single unit, module, or path will not disrupt operations.

F.2.3 N+2 redundancy

N+2 redundancy provides two additional units, modules, paths, or systems in addition to the minimum required to satisfy the base requirement. The failure or maintenance of any two single units, modules, or paths will not disrupt operations.

F.2.4 2N redundancy

2N redundancy provides two complete units, modules, paths, or systems for every one required for a base system. Failure or maintenance of one entire unit, module, path, or system will not disrupt operations.

F.2.5 2(N+1) redundancy

2 (N+1) redundancy provides two complete (N+1) units, modules, paths, or systems. Even in the event of failure or maintenance of one unit, module, path, or system, some redundancy will be provided and operations will not be disrupted.

F.2.6 Concurrent maintainability and testing capability

The facilities should be capable of being maintained, upgraded, and tested without interruption of operations.

F.2.7 Capacity and scalability

Data centers and support infrastructure should be designed to accommodate future growth with little or no disruption to services.

F.2.8 Isolation

Data centers should be (where practical) used solely for the purposes for which they were intended and should be isolated from non-essential operations.

F.2.9 Data center tiering

The four data center tiers as originally defined by The Uptime Institute in its white paper ”Industry Standard Tier Classifications Define Site Infrastructure Performance” are:

Tier I Data Center: Basic

A Tier I data center is susceptible to disruptions from both planned and unplanned activity. If it has UPS or generators, they are single-module systems and have many single points of failure. The infrastructure should be completely shut down on an annual basis to perform preventive maintenance and repair work. Urgent situations may require more frequent shutdowns. Operation errors or spontaneous failures of site infrastructure components will cause a data center disruption.

Tier II Data Center: Redundant Components

Tier II facilities with redundant components are slightly less susceptible to disruptions from both planned and unplanned activity than a basic data center. They have UPS, and engine generators, but their capacity design is “Need plus One” (N+1), which has a single-threaded distribution path throughout. Maintenance of the critical power path and other parts of the site infrastructure will require a processing shutdown.

Tier III Data Center: Concurrently Maintainable

Tier III level capability allows for any planned site infrastructure activity without disrupting the computer hardware operation in any way. Planned activities include preventive and programmable maintenance, repair and replacement of components, addition or removal of capacity components, testing of components and systems, and more. Sufficient capacity and distribution must be available to simultaneously carry the load on one path while performing maintenance or testing on the other path. Unplanned activities such as errors in operation or spontaneous failures of facility infrastructure components may still cause a data center disruption.

Tier IV Data Center: Fault Tolerant

Tier IV provides site infrastructure capacity and capability to permit any planned activity without disruption to the critical load. Fault-tolerant functionality also provides the ability of the site infrastructure to sustain at least one worst-case unplanned failure or event with no critical load impact. This requires simultaneously active distribution paths, typically in a System+System configuration.

F.3 Telecommunications

Figure 12 in clause 9 illustrates data center telecommunications cabling pathway infrastructure redundancy at various tiers.

F.3.1 Tier 1 (telecommunications)

In addition to the requirements and guidelines in this standard, a tier 1 facility will have one customer owned maintenance hole and entrance pathway to the facility. The access provider services will be terminated within one entrance room. The communications infrastructure will be distributed from the entrance room to the main distribution and horizontal distribution areas (HDAs) throughout the data center via a single pathway. Although logical redundancy may be built into the network topology, there would be no physical redundancy or diversification provided within a tier 1 facility.

Some potential single points of failure of a tier 1 facility are:

- access provider outage, central office outage, or disruption along a access provider right-of-way;
- access provider equipment failure;
- router or switch failure, if they are not redundant;
- any catastrophic event within the entrance room, main distribution area (MDA), or maintenance hole may disrupt all telecommunications services to the data center; and
- damage to backbone or horizontal cabling.

F.3.2 Tier 2 (telecommunications)

The telecommunications infrastructure should meet the requirements of tier 1.

Critical telecommunications equipment, access provider provisioning equipment, production routers, production LAN switches, and production SAN switches, should have redundant components (power supplies, processors).

Intra-data center LAN and SAN backbone cabling from switches to backbone switches should have redundant fiber or wire pairs within the overall star configuration. The redundant connections may be in the same or different cable sheaths.

Logical configurations are possible and may be in a ring or mesh topology superimposed onto the physical star configuration.

A tier 2 facility addresses vulnerability of telecommunications services entering the building.

A tier 2 facility should have two customer owned maintenance holes and entrance pathways to the facility. The two redundant entrance pathways will be terminated within one entrance room.

All patch cords and jumpers should be labeled at both ends of the cable with the name of the connection at both ends of the cable.

Some potential single points of failure of a tier 2 facility are:

- access provider equipment located in the entrance room connected to same electrical distribution and supported by single HVAC components or systems;
- redundant LAN or SAN switches connected to same electrical circuit or supported by single HVAC components or systems; and
- any catastrophic event within the entrance room or MDA may disrupt all telecommunications services to the data center.

F.3.3 Tier 3 (telecommunications)

The telecommunications infrastructure should meet the requirements of tier 2.

The data center should be served by at least two access providers. Service should be provided from at least two different access provider central offices or points-of-presences. Access provider cabling from their central offices or points-of-presences should be separated by at least 20 m (66 ft) along their entire route for the routes to be considered diversely routed.

The data center should have two entrance rooms preferably at opposite ends of the data center but a minimum of 20 m (66 ft) physical separation between the two rooms. Do not share access provider provisioning equipment, fire protection zones, power distribution units, and air conditioning equipment between the two entrance rooms. The access provider provisioning equipment in each entrance room should be able to continue operating if the equipment in the other entrance room fails.

The data center should have redundant backbone pathways between the entrance rooms, MDA, intermediate distribution areas (IDAs), and HDAs.

Intra-data center LAN and SAN backbone cabling from switches to backbone switches should have redundant fiber or wire pairs within the overall star configuration. The redundant connections should be in diversely routed cable sheathes.

There should be a “hot” standby backup for all critical telecommunications equipment, access provider provisioning equipment, core layer production routers and core layer production LAN/SAN switches.

All cabling, cross-connects and patch cords should be documented using software systems or automated infrastructure management systems as described in the ANSI/TIA-606-B.

Some potential single points of failure of a tier 3 facility are:

- any catastrophic event within the MDA may disrupt all telecommunications services to the data center; and
- any catastrophic event within a HDA may disrupt all services to the area it servers.

F.3.4 Tier 4 (telecommunications)

The telecommunications infrastructure should meet the requirements of tier 3.

Data center backbone cabling and distributor locations should be redundant. Cabling between two spaces should follow physically separate routes, with common paths only inside the two end spaces. Backbone cabling should be protected by routing through conduit or by use of cables with interlocking armor.

There should be automatic backup for all critical telecommunications equipment, access provider provisioning equipment, core layer production routers and core layer production LAN/SAN switches. Sessions/connections should switch automatically to the backup equipment.

The data center should have redundant MDAs preferably at opposite ends of the data center, but a minimum of 20 m (66 ft) physical separation between the two spaces. Do not share fire protection zones, power distribution units, and air conditioning equipment between the redundant

MDAs. The redundant MDA is optional, if the computer room is a single continuous space, as there is probably little to be gained by implementing two MDAs in this case.

The two MDAs should have separate pathways to each entrance room. There should also be a pathway between the MDAs.

The redundant routers and switches should be distributed between redundant distribution spaces (e.g. redundant MDAs, redundant pair of IDAs, or redundant pair of HDAs, or redundant pair of entrance rooms).

Each HDA should be provided with connectivity to two different IDAs or MDAs. Similarly, each IDA should be provided with connectivity to both MDAs.

Critical systems should have horizontal cabling to two HDAs.

Some potential single points of failure of a tier 4 facility are at:

- the MDA (if the secondary distribution area is not implemented); and
- the HDA and horizontal cabling (if redundant horizontal cabling is not installed).

F.4 Architectural and structural

F.4.1 General

The building structural system should be either steel or concrete. At a minimum, the building frame should be designed to withstand wind loads in accordance with the applicable building codes for the location under consideration and in accordance with provisions for structures designated as essential facilities (for example, Building Classification III from the International Building Code).

F.4.2 Tier 1 (architectural)

Architecturally, a tier 1 data center is a data center with no requirements for protection against physical events, intentional or accidental, natural or man-made, which could cause the data center to fail.

F.4.3 Tier 2 (architectural)

Tier 2 installations should meet all requirements of tier 1. A tier 2 data center includes additional minimal protections against some physical events, intentional or accidental, natural or man-made, which could cause the data center to fail.

F.4.4 Tier 3 (architectural)

Tier 3 installations should meet all requirements of tier 2. A tier 3 data center has protection against most physical events, intentional or accidental, natural or manmade, which could cause the data center to fail.

F.4.5 Tier 4 (architectural)

A tier 4 data center has considered all potential physical events that could cause the data center to fail. A tier 4 data center has provided specific and in some cases redundant protections against such events. Tier 4 data centers consider the potential problems with natural disasters such as seismic events, floods, fire, hurricanes, and storms, as well as potential problems with terrorism and disgruntled employees. Tier 4 data centers have control over all aspects of their facility.

F.5 Electrical

F.5.1 Tier 1 (electrical)

A tier 1 facility provides the minimum level of power distribution to meet the electrical load requirements, with little or no redundancy. The electrical systems are single path, whereby a failure of or maintenance to a panel or feeder will cause partial or total interruption of operations. No redundancy is required in the utility service entrance.

Generators may be installed as single units or paralleled for capacity, but there is no redundancy requirement. One or more automatic transfer switches are typically used to sense loss of normal power, initiation of generator start and transfer of loads to the generator system. Isolation-bypass automatic transfer switches (ATSs) or automatic transfer circuit breakers are used for this purpose but not required. Permanently installed load banks for generator and UPS testing are not required. Provision to attach portable load banks is required.

The uninterruptible power supply system can be installed as a single unit or paralleled for capacity. Static, rotary or hybrid UPS technologies can be utilized, with either double conversion or line interactive designs. Compatibility of the UPS system with the generator system is required. The UPS system should have a maintenance bypass feature to allow continuous operation during maintenance of the UPS system.

Separate transformers and panel boards are acceptable for the distribution of power to the critical electronic loads in tier 1 data centers. The transformers should be designed to handle the non-linear load that they are intended to feed. Harmonic canceling transformers can also be used in lieu of K-rated transformers.

Power distribution units (PDU) or discrete transformers and panel boards may be used to distribute power to the critical electronic loads. Any code compliant wiring method may be utilized. Redundancy is not required in the distribution system. Grounding system should conform to minimum code requirements.

Monitoring of electrical and mechanical systems is optional.

F.5.2 Tier 2 (electrical)

Tier 2 installations should meet all requirements of tier 1. In addition,

A tier 2 facility provides for N+1 redundant UPS modules. A generator system sized to handle all data center loads is required, although redundant generator sets are not required. No redundancy is required in the utility service entrance or power distribution system.

Provisions to connect portable load banks should be provided for generator and UPS testing.

Power distribution units (PDUs) should be used to distribute power to the critical electronic loads. Panel boards or PDU “sidecars” may be sub-fed from PDUs where additional branch circuits are required. Two redundant PDUs, each preferably fed from a separate UPS system, should be provided to serve each computer equipment rack; single cord and three cord computer equipment should be provided with a rack-mount fast-transfer switch or static switch fed from each PDU. Alternatively, dual-fed static-switch PDUs fed from separate UPS systems can be provided for single cord and three-cord equipment, although this arrangement offers somewhat less redundancy and flexibility. Color-coding of nameplates and feeder cables to differentiate A and B distribution should be considered, for example, all A-side white, all B-side blue.

A circuit should not serve more than one rack to prevent a circuit fault from affecting more than one rack. To provide redundancy, racks and cabinets should each have two dedicated electrical circuits fed from two different Power Distribution Units (PDUs) or electrical panels. Each receptacle should be identified with the PDU and circuit number, which serves it. Redundant feeder to mechanical system distribution board is recommended but not required.

F.5.3 Tier 3 (electrical)

Tier 3 installations should meet all requirements of tier 2.

All systems of a tier 3 facility should be provided with at least N+1 redundancy at the module, pathway, and system level, including the generator and UPS systems, the distribution system, and all distribution feeders. The configuration of mechanical systems should be considered when designing the electrical system to ensure that N+1 redundancy is provided in the combined electrical-mechanical system. This level of redundancy can be obtained by either furnishing two sources of power to each air conditioning unit, or dividing the air conditioning equipment among multiple sources of power. Feeders and distribution boards are dual path, whereby a failure of or maintenance to a cable or panel will not cause interruption of operations. Sufficient redundancy should be provided to enable isolation of any item of mechanical or electrical equipment as required for essential maintenance without affecting the services being provided with cooling. By employing a distributed redundant configuration, single points of failure are virtually eliminated from the utility service entrance down to the mechanical equipment, and down to the PDU or computer equipment.

To increase the availability of power to the critical load, the distribution system is configured in a distributed isolated redundant (dual path) topology. This topology requires the use of automatic static transfer switches (ASTS) placed either on the primary or secondary side of the PDU transformer. Automatic static transfer switches (ASTS) requirements are for single cord load only. For dual cord (or more) load design, affording continuous operation with only one cord energized, no automatic static transfer switches (ASTS) is used, provided the cords are fed from different UPS sources. The automatic static transfer switches (ASTS) will have a bypass circuit and a single output circuit breaker.

A central power and environmental monitoring and control system (PEMCS) should be provided to monitor all major electrical equipment such as main switchgears, generator systems, UPS systems, automatic static transfer switches (ASTS), power distribution units, automatic transfer switches, motor control centers, transient voltage surge suppression systems, and mechanical systems. A separate programmable logic control system should be provided, programmed to manage the mechanical system, optimize efficiency, cycle usage of equipment and indicate alarm condition.

F.5.4 Tier 4 (electrical)

Tier 4 installations should meet all requirements of tier 3.

Tier 4 facilities should be designed in a ‘2(N+1)’ configuration in all modules, systems, and pathways. All feeders and equipment should be capable of manual bypass for maintenance or in the event of failure. Any failure will automatically transfer power to critical load from failed system to alternate system without disruption of power to the critical electronic loads.

A battery monitoring system capable of individually monitoring the impedance or resistance of each cell and temperature of each battery jar and alarming on impending battery failure should be provided to ensure adequate battery operation.

The utility service entrances should be dedicated to the data center and isolated from all non-critical facilities.

The building should have at least two utility feeders from different utility substations for redundancy.

F.6 Mechanical systems

F.6.2 Tier 1 (mechanical)

The HVAC system of a tier 1 facility includes single or multiple air conditioning units with the combined cooling capacity to maintain critical space temperature and relative humidity at design conditions with no redundant units. If these air conditioning units are served by a water-side heat rejection system, such as a chilled water or condenser water system, the components of these systems are likewise sized to maintain design conditions, with no redundant units. The piping system or systems are single path, whereby a failure of or maintenance to a section of pipe will cause partial or total interruption of the air conditioning system.

If a generator is provided, all air-conditioning equipment should be powered by the standby generator system.

F.6.2 Tier 2 (mechanical)

The HVAC system of a tier 2 facility includes multiple air conditioning units with the combined cooling capacity to maintain critical space temperature and relative humidity at design conditions, with one redundant unit (N+1). If these air conditioning units are served by a water system, the components of these systems are likewise sized to maintain design conditions, with one redundant unit(s). The piping system or systems are single path, whereby a failure of or maintenance to a section of pipe will cause partial or total interruption of the air conditioning system.

Air-conditioning systems should be designed for continuous operation 7 days/24 hours/365 days/year, and incorporate a minimum of N+1 redundancy in the Computer Room Air Conditioning (CRAC) units.

The computer room air conditioners (CRAC) system should be provided with N+1 redundancy, with a minimum of one redundant unit for every three or four required units.

All air-conditioning equipment should be powered by the standby generator system.

Power circuits to the air-conditioning equipment should be distributed among a number of power panels/distribution boards to minimize the effects of electrical system failures on the air-conditioning system.

All temperature control systems should be powered through redundant dedicated circuits from the UPS.

Air supply to the data center should be coordinated with the types and layouts of the server racks to be installed. The air handling plant should have sufficient capacity to support the total projected heat load from equipment, lighting, the environment, etc., and maintain constant relative humidity levels within the data center. The required cooling capacity should be calculated based on the kW (not kVA) supply available from the UPS system.

Redundancy and isolation should be provided in the fuel storage system to ensure that fuel system contamination or a mechanical fuel system failure does not affect the entire generator system.

F.6.3 Tier 3 (mechanical)

The HVAC system of a tier 3 facility includes multiple air conditioning units with the combined cooling capacity to maintain critical space temperature and relative humidity at design conditions, with sufficient redundant units to allow failure of or service to one electrical switchboard. If these air conditioning units are served by a water-side heat rejection system, such as a chilled water or condenser water system, the components of these systems are likewise sized to maintain design conditions, with one electrical switchboard removed from service. This level of redundancy can be obtained by either furnishing two sources of power to each air conditioning unit, or dividing the air conditioning equipment among multiple sources of power. The piping system or systems are dual path, whereby a failure of or maintenance to a section of pipe will not cause interruption of the air conditioning system.

Redundant computer room air conditioning (CRAC) units should be served from separate panels to provide electrical redundancy. All computer room air conditioners (CRAC) units should be backed up by generator power.

Refrigeration equipment with N+1, N+2, 2N, or 2(N+1) redundancy should be dedicated to the data center. Sufficient redundancy should be provided to enable isolation of any item of equipment as required for essential maintenance without affecting the services being provided with cooling.

Subject to the number of Precision Air Conditioners (PAC’s) installed, and consideration of the maintainability and redundancy factors, cooling circuits to the Precision Air Conditioners (PAC's) should be sub-divided. If chilled water or water-cooled systems are used, each data center dedicated sub-circuit should have independent pumps supplied from a central water ring circuit. A water loop should be located at the perimeter of the data center and be located in a sub floor trough to contain water leaks to the trough area. Leak detection sensors should be installed in the trough. Consideration should be given to fully isolated and redundant chilled water loops.

F.6.4 Tier 4 (mechanical)

The HVAC system of a tier 4 facility includes multiple air conditioning units with the combined cooling capacity to maintain critical space temperature and relative humidity at design conditions, with sufficient redundant units to allow failure of or service to one electrical switchboard. If these air conditioning units are served by a water-side heat rejection system, such as a chilled water or condenser water system, the components of these systems are likewise sized to maintain design conditions, with one electrical switchboard removed from service. This level of redundancy can be obtained by either furnishing two sources of power to each air conditioning unit, or dividing the air conditioning equipment among multiple sources of power. The piping system or systems are dual path, whereby a failure of or maintenance to a section of pipe will not cause interruption of the air conditioning system. Alternative resources of water storage are to be considered when evaporative systems are in place for a tier 4 system.

Table 10: Tiering reference guide (telecommunications)

	TIER 1 (T_1)	TIER 2 (T_2)	TIER 3 (T_3)	TIER 4 (T_4)
TELECOMMUNICATIONS				
General				
Cabling, racks, cabinets, & pathways compliant with relevant TIA specifications	yes	yes	yes	yes
Diversely routed access provider entrances and maintenance holes with minimum 20 m separation	not required	yes	yes	yes
Redundant access provider services – multiple access providers, central offices, access provider right-of-ways	not required	not required	yes	yes
Redundant entrance room	not required	not required	yes	yes
Redundant main distribution area	not required	not required	not required	yes
Redundant intermediate distribution areas (if present)	not required	not required	not required	yes
Redundant backbone cabling and pathways	not required	not required	yes	yes
Redundant horizontal cabling and pathways	not required	not required	not required	yes
Routers and switches have redundant power supplies, processors	not required	yes	yes	yes
Redundant routers and switches with redundant uplinks	not required	not required	yes	yes
Patch panels, outlets, and cabling to be labeled per ANSI/TIA-606-B. Cabinets and racks to be labeled on front and rear.	yes	yes	yes	yes
Patch cords and jumpers to be labeled on both ends with the name of the connection at both ends of the cable	not required	yes	yes	yes
Patch panel and patch cable documentation compliant with ANSI/TIA-606-B.	not required	not required	yes	yes

Table 11: Tiering reference guide (architectural)

	TIER 1 (A_1)	TIER 2 (A_2)	TIER 3 (A_3)	TIER 4 (A_4)
ARCHITECTURAL				
Site selection				
Proximity to flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map	not required	not within the 50-year flood hazard area	Not within 100-year flood hazard area and greater than 91 m (300 ft) from 50-year flood hazard area	Greater than 91 m (300 ft) from 100-year flood hazard area
Proximity to coastal or navigable inland waterways	not required	not required	Greater than 91 m (300 ft)	Greater than 0.8 km (1/2 mile)
Proximity to major highway traffic arteries and main rail lines	not required	not required	Greater than 91 m (300 ft)	Greater than 0.8 km (1/2 mile)
Proximity to major airports	not required	not required	Greater than 1.6 km (1 mile) and less than 48 km (30 miles)	Greater than 8 km / 5 miles and less than 48 km (30 miles)
Parking				
Separate visitor and employee parking areas	not required	not required	yes (physically separated with separate entries)	yes (physically separated by fence or wall with separate entries)
Separate from loading docks	not required	not required	yes (physically separated with separate entries)	yes (physically separated by fence or wall with separate entries)
Proximity of visitor parking to data center perimeter building walls	not required	not required	9.1 m (30 ft) minimum separation with physical barriers to prevent vehicles from driving closer	18.3 m (60 ft) minimum separation with physical barriers to prevent vehicles from driving closer
Multi-tenant occupancy within building	no restriction	Allowed only if occupancies are non-hazardous	Allowed if all tenants are data centers or telecommunications companies	Allowed if all tenants are data centers or telecommunications companies
Building construction				
Type of construction (IBC 2006)	no restriction	no restriction	Type IIA, IIIA, or VA	Type IA or 1B
Fire resistive requirements				
Exterior bearing walls	Code allowable	Code allowable	1 Hour minimum	4 Hours minimum
Interior bearing walls	Code allowable	Code allowable	1 Hour minimum	2 Hour minimum
Exterior nonbearing walls	Code allowable	Code allowable	1 Hour minimum	4 Hours minimum
Structural frame	Code allowable	Code allowable	1 Hour minimum	2 Hour minimum
Interior non-computer room partition walls	Code allowable	Code allowable	1 Hour minimum	1 Hour minimum
Interior computer room partition walls	Code allowable	Code allowable	1 Hour minimum	2 Hour minimum
Shaft enclosures	Code allowable	Code allowable	1 Hour minimum	2 Hour minimum
Floors and floor-ceilings	Code allowable	Code allowable	1 Hour minimum	2 Hour minimum
Roofs and roof-ceilings	Code allowable	Code allowable	1 Hour minimum	2 Hour minimum
Meet requirements of NFPA 75	not required	yes	yes	yes

	TIER 1 (A_1)	TIER 2 (A_2)	TIER 3 (A_3)	TIER 4 (A_4)
Miscellaneous Building components				
Vapor barriers for walls and ceiling of computer room	not required	yes for walls, not required for ceiling	yes	yes
Building entrances with security checkpoints	not required	not required	yes (primary building entrance manned)	Yes (primary building entrance manned)
Access floor panel construction (when provided)	no requirement	no requirement	computer grade all steel	Computer grade all steel or computer grade steel with concrete fill
Understructure (when access floor is provided)	no requirement	no requirement	bolted stringer	bolted stringer with 1.2 m x 1.2 m (4 ft x 4 ft) basket weave pattern
Roofing				
Class	no restrictions	Class A	Class A	Class A
Type	no restrictions	no restrictions	Non-redundant with non-combustible deck (no mechanically attached systems)	double redundant with concrete deck (no mechanically attached systems)
Wind uplift resistance	Minimum Code requirements	FM I-90	FM I-90 minimum	FM I-120 minimum
Roof Slope	Minimum Code requirements	Minimum Code requirements	1:48 (1/4 in per foot) minimum	1:24 (1/2 in per foot) minimum
Doors and windows				
Fire rating	Minimum Code requirements	Minimum Code requirements	Minimum Code requirements (not less than 3/4 hour at computer room)	Minimum Code requirements (not less than 1 1/2 hour at computer room)
Door size	Minimum Code requirements and not less than 1 m (3 ft) wide and 2.13 m (7 ft in) high	Minimum Code requirements and not less than 1 m (3 ft) wide and 2.13 m (7 ft) high	Minimum Code requirements (not less than 1 m (3 ft) wide into computer, electrical, & mechanical rooms) and not less than 2.29 m (7'-6") high	Minimum Code requirements (not less than 1.2 m (4 ft) wide into computer, electrical, & mechanical rooms) and not less than 2.49 m (8 ft) high
Windows on perimeter of computer room	Allowed with minimum Code required fire rating	Allowed with minimum Code required fire rating	Interior windows allowed with minimum 1-hour fire rating, no exterior windows allowed	Interior windows allows with minimum 2-hour fire rating, no exterior windows allowed
Entry Lobby				
Physically separate from other areas of data center	not required	yes	yes	yes
Fire separation from other areas of data center	Minimum Code requirements	Minimum Code requirements	Minimum Code requirements (not less than 1 hour)	Minimum Code requirements (not less than 2 hour)
Security counter	not required	not required	yes	yes (physically separated from other areas of the data center)
Single person interlock, portal or other hardware designed to prevent piggybacking or pass back	not required	not required	yes	yes

	TIER 1 (A_1)	TIER 2 (A_2)	TIER 3 (A_3)	TIER 4 (A_4)
Administrative offices				
Physically separate from other areas of data center	not required	yes	yes	yes
Fire separation from other areas of data center	Minimum Code requirements	Minimum Code requirements	Minimum Code requirements (not less than 1 hour)	Minimum Code requirements (not less than 2 hour)
Security office				
Physically separate from other areas of data center	not required	not required	yes	yes
Fire separation from other areas of data center	Minimum Code requirements	Minimum Code requirements	Minimum Code requirements (not less than 1 hour)	Minimum Code requirements (not less than 2 hour)
180-degree peepholes on security equipment and monitoring rooms	Not required	yes	yes	yes
Dedicated and hardened security equipment and monitoring rooms	Not required	yes	Yes, with 16 mm (5/8 in) plywood lined walls and solid core door	Yes, with 16 mm (5/8 in) plywood lined walls and solid core door
Operations Center				
Operations Center physically separate from other areas of data center	not required	not required	yes	Yes, with a backup service/facility in a separate address
Fire separation from other non-computer room areas of data center	not required	not required	1 hour	2 hour
Proximity to computer room	no requirement	no requirement	indirectly accessible (maximum of 1 adjoining room)	directly accessible
Restrooms and break room areas				
Proximity to computer room and support areas	no requirement	no requirement	If immediately adjacent, provided with leak prevention barrier	Not immediately adjacent and provided with leak prevention barrier
Fire separation from computer room and support areas	Minimum Code requirements	Minimum Code requirements	Minimum Code requirements (not less than 1 hour)	Minimum Code requirements (not less than 2 hour)
UPS and Battery Rooms				
Aisle widths for maintenance, repair, or equipment removal	no requirement	no requirement	Minimum Code requirements (not less than 1 m (3 ft) clear)	Minimum Code requirements (not less than 1.2 m (4 ft) clear)
Proximity to computer room	no requirement	no requirement	Immediately adjacent	Immediately adjacent
Fire separation from computer room and other areas of data center	Minimum Code requirements	Minimum Code requirements	Minimum Code requirements (not less than 1 hour)	Minimum Code requirements (not less than 2 hour)
Required Exit Corridors				
Fire separation from computer room and support areas	Minimum Code requirements	Minimum Code requirements	Minimum Code requirements (not less than 1 hour)	Minimum Code requirements (not less than 2 hour)
Width	Minimum Code requirements	Minimum Code requirements	Minimum Code requirements and not less than 1.2 m (4 ft) clear	Minimum Code requirements and not less than 1.5 m (5 ft) clear

	TIER 1 (A_1)	TIER 2 (A_2)	TIER 3 (A_3)	TIER 4 (A_4)
Shipping and receiving area				
Shipping and receiving area physically separate from other areas of data center	No shipping and receiving area provided	not required	yes	yes
Fire separation from other areas of data center	Minimum Code requirements if shipping and receiving area present	Minimum Code requirements	1 hour	2 hour
Physical protection of walls exposed to lifting equipment traffic	not required	not required	yes (minimum 19 mm (3/4 in) plywood wainscot)	yes (steel bollards or similar protection)
Number of loading docks	no requirement	1 per 2500 m^2 (25,000 ft^2) of Computer room	1 per 2500 m^2 (25,000 ft^2) of Computer room (2 minimum)	1 per 2500 m^2 (25,000 ft2) of Computer room (2 minimum)
Generator and fuel storage areas				
Proximity to computer room and support areas	no requirement	no requirement	If within Data Center building, provided with minimum 2 hour fire separation from all other areas	Separate building or exterior weatherproof enclosures with Code required building separation
Proximity to publicly accessible areas	no requirement	no requirement	9 m (30 ft) or greater separation	19 m (60 ft) or greater separation
Security				
System CPU UPS capacity	no requirement	Building	Building	Building + Battery (8 hour min)
Data Gathering Panels (Field Panels) UPS Capacity	no requirement	Building + Battery (4 hour min)	Building + Battery (8 hour min)	Building + Battery (24 hour min)
Field Device UPS Capacity	no requirement	Building + Battery (4 hour min)	Building + Battery (8 hour min)	Building + Battery (24 hour min)
Physical security staffing	no requirement	During scheduled operation (typically 5 days a week during normal business hours)	7 days a week, 24 hours a day	7 days a week, 24 hours a day with sufficient spare personnel to allow for physical inspections, walk alongs, supervisions etc

	TIER 1 (A_1)	TIER 2 (A_2)	TIER 3 (A_3)	TIER 4 (A_4)
Security Access Control/Monitoring at:				
Generators	industrial grade lock	intrusion detection	card access	card access
UPS, Telephone & MEP Rooms	industrial grade lock	intrusion detection	card access	card access
Fiber Vaults	industrial grade lock	intrusion detection	intrusion detection	card access
Emergency Exit Doors	industrial grade lock	monitor	delay egress per code	delay egress per code
Accessible Exterior Windows/openings	no requirement	intrusion detection (with offsite monitoring during shifts when no security staff is present)	intrusion detection	intrusion detection
Security Operations Center	no requirement	no requirement	card access	card access
Network Operations Center	no requirement	no requirement	card access	card access
Security Equipment Rooms	no requirement	intrusion detection	card access	card access
Doors into Computer Rooms	industrial grade lock	intrusion detection	card or biometric access for ingress	card or biometric access for ingress and egress (Unauthorized egress shall be alarmed and monitored, but unrestricted at all times for life/safety)
Perimeter building doors	no requirement	intrusion detection (with offsite monitoring during shifts when no security staff is present)	card access if main entrance; intrusion detection all others	card access all entrances
Main door onto computer room floor	industrial grade lock	card access	Single person interlock, portal or other hardware designed to prevent piggybacking or pass back of access credential	single person interlock, portal or other hardware designed to prevent piggybacking or pass back of access credential, preferably with biometrics
Bullet resistant walls, windows & doors				
Security Counter in Lobby	no requirement	no requirement	Level 3 (min)	Level 3 (min)
CCTV Monitoring				
Building perimeter and parking	not required	not required	yes	yes
Generators	not required	not required	yes	yes
Access Controlled Doors	not required	yes	Yes	Yes
Computer Room Floors	not required	not required	Yes	Yes
UPS, Telephone & MEP Rooms	not required	not required	Yes	Yes
CCTV				
CCTV Recording of all activity on all cameras	not required	not required	Yes; digital	Yes; digital
Recording rate (frames per second)	no requirement	no requirement	20 frames/sec (min)	20 frames/sec (min)

	TIER 1 (A_1)	TIER 2 (A_2)	TIER 3 (A_3)	TIER 4 (A_4)
Structural				
Facility design to International Building Code (IBC) Seismic Design Category (SDC) requirements	Use SDC requirements for building location	Use SDC requirements for building location	Use SDC requirements for building location	Use appropriate SDC requirements for the site with SDC-C being the minimum
Site Specific Response Spectra - Degree of local Seismic accelerations	no requirement	no requirement	with Operation Status after 10% in 50 year event	with Operation Status after 5% in 100 year event
Importance factor - assists to ensure greater than code design	I=1	I=1.5	I=1.5	I=1.5
Telecommunications equipment racks/cabinets anchored to base or supported at top and base	no requirement	Base only	Fully braced	Fully braced
Deflection limitation on telecommunications equipment within limits acceptable by the electrical attachments	not required	not required	yes	yes
Bracing of electrical conduits runs and cable trays	per code	per code w/ Importance	per code w/ Importance	per code w/ Importance
Bracing of mechanical system major duct runs	per code	per code w/ Importance	per code w/ Importance	per code w/ Importance
Floor loading capacity superimposed live load	7.2 kPa (150 lbf/ft^2).	8.4 kPa (175 lbf/ft^2)	12 kPa (250 lbf/ft^2)	12 kPa (250 lbf/ft^2)
Floor hanging capacity for ancillary loads suspended from below	1.2 kPa (25 lbf/ft^2)	1.2 kPa (25 lbf/ft^2)	2.4 kPa (50 lbf/ft^2)	2.4 kPa (50 lbf/ft^2)
Concrete Slab Thickness at ground	127 mm (5 in)	127 mm (5 in)	127 mm (5 in)	127 mm (5 in)
Minimum concrete topping over flutes for equipment anchorage when concrete filled metal deck structure used for elevated floors	102 mm (4 in)	102 mm (4 in)	102 mm (4 in)	102 mm (4 in)
Building LFRS (Shearwall/Braced Frame/Moment Frame) indicates displacement of structure	Steel/Concrete Moment Frame	Concrete Shearwall / Steel Braced Frame	Concrete Shearwall / Steel Braced Frame	Concrete Shearwall / Steel Braced Frame
Building Energy Dissipation - Passive Dampers/Base Isolation (energy absorption)	Not required	Not required	passive dampers for IBC Seismic Design Category D or higher	passive dampers/base isolation for IBC Seismic Design Category D or higher
Elevated floor construction. (Steel structures with concrete filled metal decks are more easily upgraded for intense loads in Battery/UPS rooms. (Also, better for installing floor anchors).	PT concrete	CIP Mild Concrete	Steel Deck & Fill	Steel Deck & Fill

Table 12: Tiering reference guide (electrical)

	TIER 1 (E_1)	TIER 2 (E_2)	TIER 3 (E_3)	TIER 4 (E_4)
ELECTRICAL				
General				
System allows concurrent maintenance	Not required	Utility, generator, and UPS system	From utility down to but not including power distribution unit	Throughout Distribution System
Single Point of Failure	Multiple single points of failure throughout the distribution system	Multiple single points of failure throughout the distribution system	Single point of failure from last distribution panel to critical and essential load only	No single points of failure for distribution systems serving electrical equipment or essential load
Power System Analysis	Up-to-date short circuit study, coordination study, and arc flash analysis	Up-to-date short circuit study, coordination study, and arc flash analysis	Up-to-date short circuit study, coordination study, arc flash analysis, and load flow study	Up-to-date short circuit study, coordination study, arc flash analysis, and load flow study
Computer & Telecommunications Equipment Power Cords	Single Cord Feed with 100% capacity	Single Cord Feed with 100% capacity	Redundant Cord Feed with 100% capacity on remaining cord or cords	Redundant Cord Feed with 100% capacity on remaining cord or cords
Utility				
Utility Entrance	Single Feed	Single Feed	N+1 Redundant Feed	2N Redundant Feed from different utility substations or generator plant
Main Utility Switchboard				
Service	Shared	Shared	Dedicated	Dedicated
Construction	Panel board with bolt on circuit breakers	Switchboard with stationary circuit breakers	Switchboard with draw out circuit breakers	Switchgear with draw out circuit breakers
Surge Suppression	Not required	Not required	Yes	Yes

	TIER 1 (E_1)	TIER 2 (E_2)	TIER 3 (E_3)	TIER 4 (E_4)
Uninterruptible Power Supply System				
Redundancy	N	N	N+1	2N
Topology	Single or Parallel-Modules	Single or Parallel Modules	Distributed Redundant Modules or Block Redundant System	Distributed Redundant Modules or Block Redundant System
Automatic Bypass	Not required	Yes with non dedicated feeder to automatic bypass	Yes, with dedicated feeder to automatic bypass	Yes, with dedicated feeder to automatic bypass
Maintenance Bypass Arrangement	Not required	Non dedicated maintenance bypass feeder to UPS output switchboard	Dedicated maintenance bypass feeder serving UPS output switchboard	Dedicated maintenance bypass feeder serving UPS output switchboard
Output Power Distribution	Panel board incorporating standard thermal magnetic trip breakers	Panel board incorporating standard thermal magnetic trip breakers	Switchboard incorporating removable circuit breaker with adjustable long time and instantaneous trip function	Switchboard incorporating removable circuit breaker with adjustable long time, short time and instantaneous functions with provision to turn off instantaneous function
Battery String	Common String for multiple modules	Dedicated String for each module	Dedicated String for each module	Dedicated String for each module
Battery type	5 Year valve regulated lead acid or flywheel	10 Year valve regulated lead acid or flooded type or flywheel	15 Year valve regulated lead acid or flooded type or flywheel	20 Year lead acid flooded type or flywheel
Battery minimum back up time with design load at end of battery life	5 minutes	7 minutes	10 minutes	15 minutes
Battery Monitoring System	Not required	Not required	String level by UPS System	Centralized automated system to check each cell for, voltage, and impedance or resistance
Power Distribution Unit				
Transformer	Standard high efficiency	Standard high efficiency	K-Rated or harmonic cancelling, high efficiency	K-Rated or harmonic cancelling, low Inrush high efficiency
Automatic Static Transfer Switch				
Over-current Device	Not required	Not required	Circuit Breaker	Circuit Breaker
Maintenance Bypass Procedure	Not required	Not required	Manual Guided with mechanical interlock	Automatic operation
Output	No requirement	No requirement	Dual Circuit Breaker	Dual Circuit Breaker

	TIER 1 (E_1)	TIER 2 (E_2)	TIER 3 (E_3)	TIER 4 (E_4)
Grounding				
Lightning protection system	Based on risk analysis as per NFPA 780 and insurance requirements.	Based on risk analysis as per NFPA 780 and insurance requirements.	Yes	Yes
Lighting fixtures neutral isolated from service entrance derived from lighting transformer for ground fault isolation	Not required	Not required	Yes	Yes
Data center grounding infrastructure in computer room	As required by ANSI/TIA-607-B	As required by ANSI/TIA-607-B	As required by ANSI/TIA-607-B	As required by ANSI/TIA-607-B
Computer Room Emergency Power Off (EPO) System				
Installation	If required by AHJ, push to activate with cover guard and warning label	If required by AHJ, push to activate with cover guard and warning label	If required by AHJ, push to activate with cover guard and warning label	If required by AHJ, push to activate with cover guard and warning label
Test Mode	Not required	Not required	Yes	Yes
Alarm	Not required	Not required	Yes	Yes
Abort Switch	Not required	Not required	As allowed by local codes	As allowed by local codes
Central Power Monitoring				
Monitored Points	Not required	Utility UPS Generator	Utility, Main Transformer, UPS, Generator, Feeder Circuit Breakers, Automatic Static Transfer Switch, PDU, Automatic Transfer Switches	Utility, Main Transformer, UPS, Generator, Feeder Circuit Breakers, Automatic Static Transfer Switch, PDU, Automatic Transfer Switches, Surge Protection Device, Critical Load Branch Circuits
Notification Method	Not required	Control Room Console	Control Room Console, Pager, Email, and/or text message	Control Room Console, Pager, Email, and/or text message to multiple facility personnel
Battery Room				
Separate from UPS/Switchgear Equipment Rooms	Not required	Not required	Yes	Yes
Individual Battery Strings Isolated from Each Other	Not required	Not required	Yes	Yes
Shatterproof Viewing Glass in Battery Room Door	Not required	Not required	Not required	Yes

	TIER 1 (E_1)	TIER 2 (E_2)	TIER 3 (E_3)	TIER 4 (E_4)
Standby Generating System				
Generator Sizing	Sized for UPS System only without redundancy	Sized for UPS & mechanical system without redundancy	Sized for total building load N+1 distributed redundancy	Sized for total building load with 2N distributed redundancy
Generators on Single Bus	Yes	Yes	No	No
Loadbank				
Installation	No requirement	Provision for Portable	Provision for Portable	Permanent sized for single largest equipment
Equipment Tested	No requirement	Generator	Generator UPS	Generator UPS
Auto Shutdown	Not required	Not required	Automatic upon failure of utility	Automatic upon failure of utility
Testing				
Factory Acceptance Testing	Not required	Not required	UPS and Generator Systems	UPS and Generator Systems, Generator controls, ASTS
Site circuit breaker testing	Not required	Not required	Contact Resistance test of all circuit breakers in critical and essential paths, 225 A and higher	Primary Injection and Contact Resistance test of all circuit breakers in critical and essential paths, 225 A and higher
Commissioning	Not required	Component level	Component level and System level	Component level, system level, and integrated system including total outage testing
Equipment Maintenance				
Operation and Maintenance Staff	Offsite. On call.	Onsite Day Shift only. On-call at other times	Onsite 24 hrs M-F, on-call on weekends	Onsite 24/7
Preventative Maintenance	No requirement	Generator maintenance	Generator and UPS maintenance	Comprehensive preventative maintenance program
Facility Training Programs	No requirement	Limited training by manufacturer	Comprehensive training program for normal operation of equipment	Comprehensive training program for normal operation of equipment and manual operation of equipment during emergency operation

Table 13: Tiering reference guide (mechanical)

	TIER 1 (M_1)	TIER 2 (M_2)	TIER 3 (M_3)	TIER 4 (M_4)
MECHANICAL				
General				
Redundancy for mechanical equipment (e.g. air conditioning units, coolers, pumps, cooling towers, condensers)	Not required	N+1 redundancy for mechanical equipment. Loss of electrical power can cause loss of cooling	N+1 redundancy for mechanical equipment. Temporary loss of electrical power will not cause loss of cooling, but may cause temperature to elevate within operational range of critical equipment	N+1 redundancy for mechanical equipment. Extended loss of electrical power will not cause loss of cooling outside operational range of critical equipment
Routing of water or drain piping not associated with the data center equipment in data center spaces	Permitted but not recommended	Permitted but not recommended	Not permitted	Not permitted
Positive pressure in computer room and associated spaces relative to outdoors and non-data center spaces	Not required	Yes	Yes	Yes
Floor drains in computer room for condensate drain water, humidifier flush water, and sprinkler discharge water	Yes	Yes	Yes	Yes
Mechanical systems on standby generator	Not required	Yes	Yes	Yes
Water-Cooled System				
Indoor Terminal Air Conditioning Units	No redundant air conditioning units	One redundant AC Unit per critical area	Qty. of AC Units sufficient to maintain critical area during loss of one source of electrical power	Qty. of AC Units sufficient to maintain critical area during loss of one source of electrical power
Humidity Control for Computer Room	Not required	Humidification provided	Humidification provided	Humidification provided
Electrical Service to Mechanical Equipment	Single path of electrical power to AC equipment	Single path of electrical power to AC equipment	Multiple paths of electrical power to AC equipment. Connected in checkerboard fashion for cooling redundancy	Multiple paths of electrical power to AC equipment. Connected in checkerboard fashion for cooling redundancy
Heat Rejection				
Piping System	Single path condenser water system	Single path condenser water system	Headered parallel piped condenser water system	Dual path condenser water system
Chilled Water Piping System	Single path chilled water system	Single path chilled water system	Dual path ladder loop chilled water system with isolation valves	Dual path chilled water system
Condenser Water Piping System	Single path condenser water system	Single path condenser water system	Headered parallel piped condenser water system	Dual path condenser water system

	TIER 1 (M_1)	TIER 2 (M_2)	TIER 3 (M_3)	TIER 4 (M_4)
Chilled Water System				
Humidity Control for Computer Room	Not required	Humidification provided	Humidification provided	Humidification provided
Electrical Service to Mechanical Equipment	Single path of electrical power to AC equipment	Single path of electrical power to AC equipment	Multiple paths of electrical power to AC equipment	Multiple paths of electrical power to AC equipment
Air-Cooled System				
Electrical Service to Mechanical Equipment	Single path of electrical power to AC equipment	Single path of electrical power to AC equipment	Multiple paths of electrical power to AC equipment	Multiple paths of electrical power to AC equipment
Humidity Control for Computer Room	Not required	Humidification provided	Humidification provided	Humidification provided
HVAC Control System				
HVAC Control System	Control system failure will interrupt cooling to critical areas	Control system failure will not interrupt cooling to critical areas	Control system failure will not interrupt cooling to critical areas	Control system failure will not interrupt cooling to critical areas
Power Source to HVAC Control System	Single path of electrical power to HVAC control system	Redundant, UPS electrical power to BMS Control	Redundant, UPS electrical power to BMS Control	Redundant, UPS electrical power to BMS Control
Plumbing (for water-cooled heat rejection)				
Make-up Water	Single water supply, with no on-site back-up storage	Dual sources of water, or one source + on-site storage	Dual sources of water, or one source + on-site storage	Dual sources of water, or one source + on-site storage
Points of Connection to Condenser Water System	Single point of connection	Single point of connection	Two points of connection	Two points of connection
Fuel Oil System				
Bulk Storage Tanks	Single storage tank	Single storage tanks	Multiple storage tanks	Multiple storage tanks
Storage Tank Pumps and Piping	Single pump and/or supply pipe	Multiple pumps, multiple supply pipes	Multiple pumps, multiple supply pipes	Multiple pumps, multiple supply pipes
Fire Suppression				
Fire detection system	yes	yes	yes	yes
Fire sprinkler system	When required	Pre-action (when required)	Pre-action (when required)	Pre-action (when required)
Gaseous suppression system	No requirement above AHJ	No requirement above AHJ	clean agents listed in NFPA 2001	clean agents listed in NFPA 2001
Early Warning Smoke Detection System	No requirement above AHJ	yes	yes	yes
Water Leak Detection System	No requirement above AHJ	yes	yes	yes

ANNEX G (INFORMATIVE) DATA CENTER DESIGN EXAMPLES

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

G.1 Small data center design example

One example layout for a small data center is shown below. This is an example of a data center that is small enough to be supported by a main distribution area and no horizontal distribution areas (HDAs).

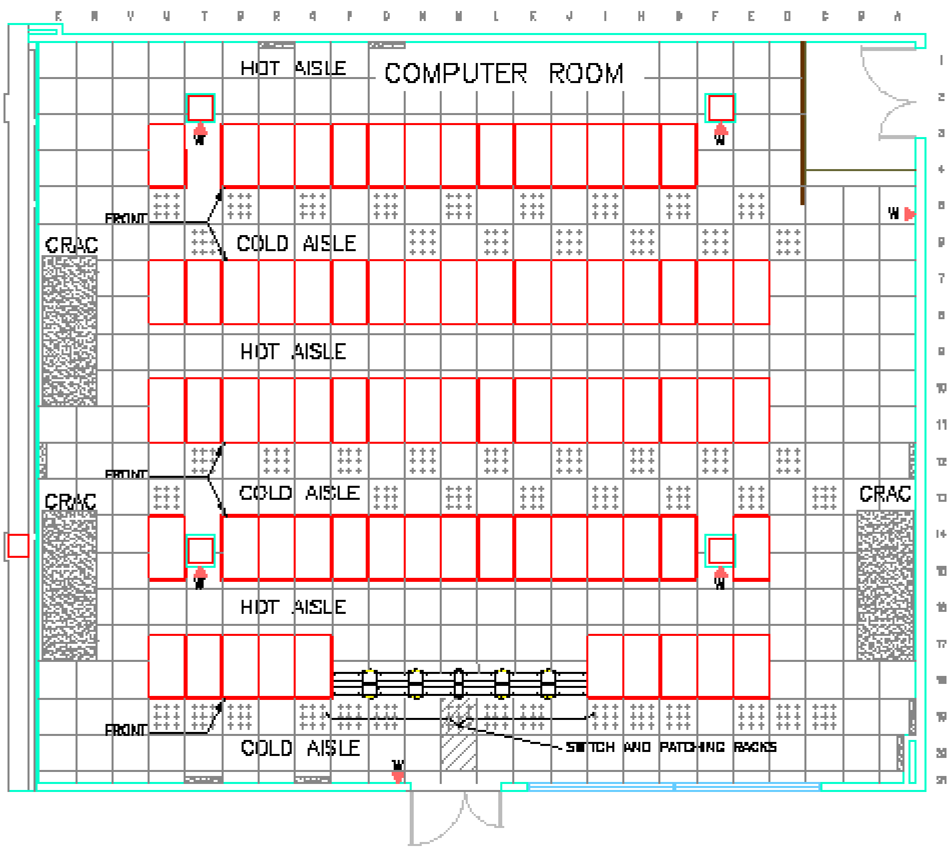

Figure 15: Computer room layout showing "hot" and "cold" aisles

This computer room space is about 1,920 square feet. It has 73 server cabinets in the equipment distribution areas (EDAs) and six 19" racks in the main distribution area (MDA). The six MDA racks are the six 'SWITCH AND PATCHING RACKS' at the bottom of the drawing. It was not necessary to put the MDA in the center of the computer room because length limitations were not an issue. However, cable lengths and cable congestion in the aisles perpendicular to the cabinet aisles could have been reduced by placing the MDA in the center of the room instead.

The MDA supports the HC for horizontal cabling to the EDAs. In a data center with a high density of cabling to the equipment cabinets, it would probably be necessary to have HDAs to minimize cable congestion near the MDA.

The rack and cabinet rows are parallel to the direction of under floor airflow created by the Computer Room Air Conditioning (CRAC) units. Each CRAC is located facing the "hot" aisles to allow more efficient return air to each CRAC unit.

Server cabinets are arranged to form alternating "hot" and "cold" aisles.

Communications cables are run in wire basket trays in the “hot” aisle. Power cables are run under the access floor in the “cold” aisles.

The computer room is separate from the Network Operations Center (NOC is not shown) for access and contaminant control.

G.2 Corporate data center design example

The following example is for an Internet or web hosting data center used to house computer and telecommunications equipment for multiple corporate web sites.

The corporate data center in this example has two floors of about 4,140 m^2 (44,500 ft^2) each. This data center is an example of a data center with several HDAs, each differentiated primarily by the type of systems that they support. Due to the density of cabling to the personal computer based servers, these systems are served by two HDAs, each supporting only 24 server cabinets. Seven additional HDAs are planned to support additional server cabinets. Thus, HDAs may be required not only for different functional areas, but also to minimize cable congestion in the HDA. Each HDA was designed to support a maximum of 2,000 4-pair balanced twisted-pair cables.

The 1st floor includes the electrical rooms, mechanical rooms, storage rooms, loading dock, security room, reception area, operations center, and entrance room.

The computer room is on the 2nd floor and is entirely on access floor. All telecommunications cabling is run under the access floor space in wire-basket cable trays. In some locations where the volume of cables is the greatest and where they do not impede airflow, the cable trays are installed in two layers. The drawing below shows the 2nd floor computer room with cable trays. In the example below, the cable trays are in blue and the IT cabinets and equipment are in gray.

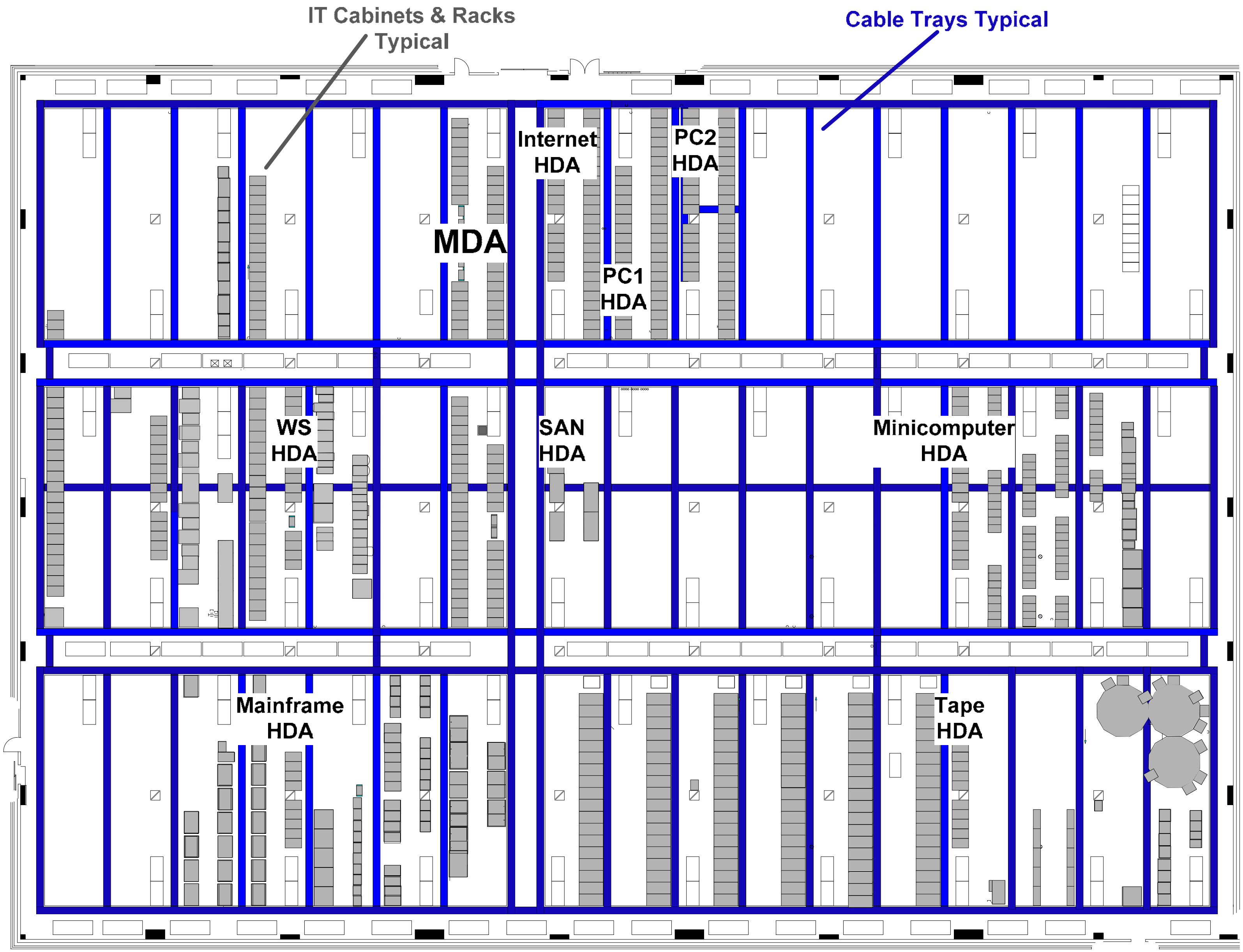

Figure 16: Example of corporate data center

Telecommunications cabling is installed in the “hot” aisles behind the server cabinets. Electrical cabling is installed in the “cold” aisles in front of the server cabinets. Both telecommunications cabling and electrical cabling follow the main aisles in the east/west direction, but follow separate pathways to maintain separation of power and telecommunications cabling.

The locations of the Entrance Room on the 1st floor and MDA on the 2nd floor are carefully positioned so that T-1 and T-3 circuits can be terminated on equipment anywhere in the computer room.

Cabinets for rack-mounted servers have standardized cabling that includes multimode fiber and balanced twisted-pair. Administration is somewhat simplified if cabinets have a standard cabling configuration.

In this data center, due to the very wide variety of cabling requirements for floor standing systems, it was not possible to develop a standardized configuration for equipment outlets in ZDAs.

G.3 Internet data center design example

The Internet data center in this example has one floor of approximately 9,500 m^2 (102,000 ft^2) with a computer room of about 6400 m^2 (69,000 ft^2). It is an example of a data center where HDAs are differentiated primarily by the area served rather than the type of systems that they support. The drawing below shows the data center floor plan with cable trays. MDA and HDA racks are shown but customer racks and cabinets are not. Cable trays and ladders are in blue. Distributor racks are black. Architectural features such as stairs, doors, and permanent walls are in red.

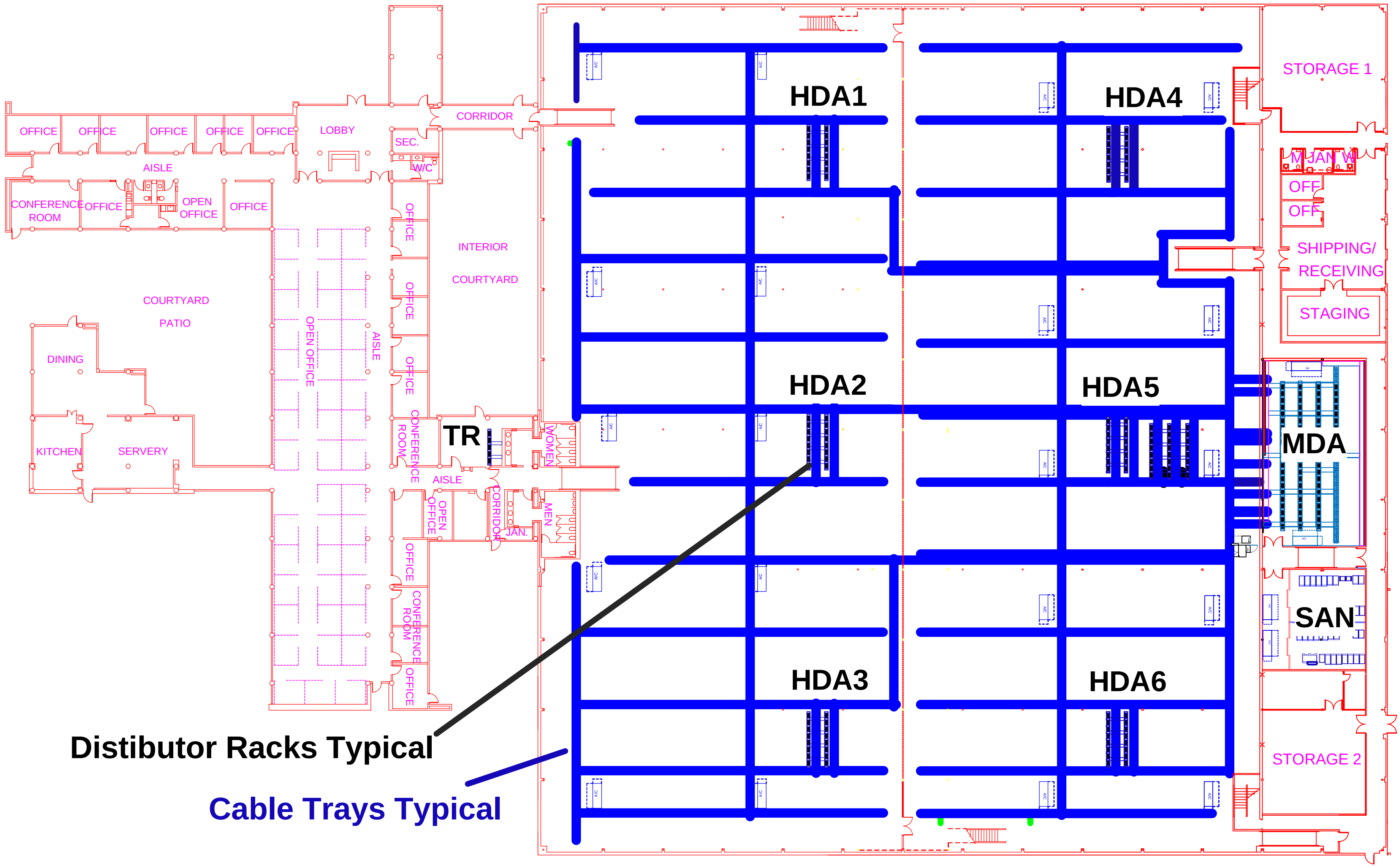

Figure 17: Example of Internet data center

The main distribution area (MDA) incorporates the function of the entrance room and the main cross-connect. It accommodates 50 access provider racks and 20 racks for the main cross-connect space. This room is supported by two dedicated PDUs, two dedicated computer room air conditioning units, and is on access floor. The MDA is in a dedicated room with a separate entrance that allows access and service providers to work in this room without entering the customer spaces in the main computer room. The locations of the MDA and HDAs were planned to ensure that circuit lengths for T-1 and T-3 circuits will not be exceeded for circuits to any rack in the computer room.

Automated tape libraries, storage servers, and control equipment for storage services are in a dedicated SAN room adjacent to the MDA. This equipment is provided and managed by third parties, not by the owner of the internet data center. A separate room for this equipment allows storage service providers to manage their equipment without entering the main computer room.

The computer room space has 4,300 customer racks. The customer space is supported by six HDAs to limit the volume of cable in the under floor cable trays. Each HDA supports approximately 2,000 balanced twisted-pair connections. These HDAs are in the center of the spaces they serve to minimize cable lengths. Cabling from the HDAs to the customer racks is standardized to simplify administration. However, additional cabling may be run to customer racks as required.

Telecommunications cabling to storage and staging areas east of the computer room are supported from the MDA. Telecommunications cabling for the offices west of the computer room are supported by a telecommunications room (TR).

ANNEX H (INFORMATIVE) BIBLIOGRAPHY

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

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

- ANSI/IEEE C2-2007, *National Electrical Safety Code®*
- ASHRAE, Best Practices for Datacom Facility Energy Efficiency, Second Edition (2009)
- ASHRAE, Design Considerations for Data and Communications Equipment Centers, Second Edition (2009)
- ASTM B539-02 2002, *Standard Test Methods for Measuring Resistance of Electrical Connections (Static Contacts)*
- BICSI *Telecommunications Distribution Methods Manual (TDMM), 12th Edition*, 2009
- BICSI *Information Transport Systems Installation Methods Manual (ITSIMM), 6th Edition*, 2010
- BICSI *Outside Plant Design Reference Manual (OSPDRM),* 5th Edition, 2010
- BOMA – *Building Owners Management Association, International – Codes & Issues, July 2000*
- CABA - *Continental Automated Buildings Association*,
- European Union, Code of Conduct on Data Centres Energy Efficiency, Version 2.0 (2010)
- European Union, Best Practices for EU Code of Conduct on Data Centres, Version 3.0 (2011)
- Federal Communications Commission (FCC) Washington D.C., "*The Code of Federal Regulations, FCC 47 CFR 68"*
- Federal Telecommunications Recommendation 1090-1997*, Commercial Building Telecommunications Cabling Standard,* by National Communications System (NCS)
- IBC, *International Building Code*
- ICC, *International Code Council*
- IEEE Std. 142*, Recommended Practice for Grounding of Industrial and Commercial Power Systems*
- IEEE Std. 446, *Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications*
- IEEE Std. 1100, *Recommended Practice for Powering and Grounding Electronic Equipment*

- ANSI/IEEE 802.3-2005, *IEEE Standard for Information technology-Telecommunications and information exchange between systems-Local and metropolitan area networks--Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*
- IEEE Standard 518-1982, *Guide for the installation of electrical equipment to minimize electrical noise to controllers of external sources*
- IFMA – *International Facility Management Association - Ergonomics for Facility Managers*, June 2000
- NFPA 72,*National Fire Alarm Code, 2010*
- NFPA 2001, *Standard on clean agent fire extinguishing systems, 2008 Edition*
- *NEC®*, *National Electrical Code, article 725, Class 1, Class 2 and Class 3 Remote-Control, Signaling and Power-Limited Circuits*.
- *NEC®*, *National Electrical Code, article 760, Fire Alarm System*.
- NEMA VE 2-2006, *cable tray installation guidelines*
- *Society of Cable Television Engineers, Inc., Document #IPS-SP-001, Flexible RF Coaxial Drop cable Specification*
- UL 444/CSA-C22.2 No. 214-94, *Communications Cables*
- The Uptime Institute White Paper, *Alternating Cold and Hot Aisles Provides More Reliable Cooling for Server Farms*
- The Uptime Institute White Paper, *Industry Standard Tier Classifications Define Site Infrastructure Performance*
- The Uptime Institute White Paper, *Fault-Tolerant Power Compliance Specification*

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

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

American Society of Heating, Refrigeration and Air conditioning Engineers (ASHRAE)
1791 Tullie Circle, NE
Atlanta, GA 30329
1-800-527-4723
(404) 636-8400
www.ashrae.org

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

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

CSA
Canadian Standards Association International (CSA)
178 Rexdale Blvd.
Etobicoke, (Toronto), Ontario
Canada M9W 1R3
(416) 747-4000
www.csa-international.org

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

FCC
Federal Communications Commission (FCC)
Washington, DC 20554
USA
(301) 725-1585
www.fcc.org

Federal and Military Specifications
National Communications System (NCS)
Technology and Standards Division
701 South Court House Road Arlington, VA 22204-2198
USA
(703) 607-6200
www.ncs.gov

International Code Council (ICC)
International Building Code (IBC)
5203 Leesburg Pike, Suite 600
Falls Church, VA 22041
703-931-4533
www.iccsafe.org

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

IEEE
The Institute of Electrical and Electronic Engineers, Inc (IEEE)
IEEE Service Center
445 Hoes Ln., PO Box 1331
Piscataway, NJ 08855-1331
USA
(732) 981-0060
www.ieee.org

IPC
The Institute for Interconnecting and Packaging Electronic Circuits
2215 Sanders Rd.
Northbrook, IL 60062-6135
USA
(847) 509-9700
www.ipc.org

ISO
International Organization for Standardization (ISO)
1, Rue de Varembe
Case Postale 56
CH-1211 Geneva 20
Switzerland
+41 22 74 901 11
www.iso.ch

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

NFPA
National Fire Protection Association (NFPA)
Batterymarch Park
Quincy, MA 02269-9101
USA
(617) 770-3000
www.nfpa.org

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

Telcordia Technologies (formerly; Bellcore)
Telcordia Technologies Customer Service
8 Corporate Place Room 3C-183
Piscataway, NJ 08854-4157
USA
(800) 521-2673
www.telcordia.com

The Uptime Institute, Inc.
1347 Tano Ridge Road
Santa Fe, NM 87506
USA
(505) 986-3900
www.upsite.com

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

UL
Underwriters Laboratories, Inc. (UL)
333 Pfingsten Road
Northbrook, IL 60062-2096
USA
(847) 272-8800
www.ul.com

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